Energy Management in the Large-Scale Manufacturing (LSM) Industries of Pakistan; Current Status, Barriers and Drivers

By

Muhammad Muneeb Ahmad

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Session 2017-19

Supervised by

Dr. Muhammad Bilal Sajid

A Thesis Submitted to the US-Pakistan Center for Advanced Studies in Energy in partial fulfillment of the requirements for the degree of

MASTER of SCIENCE in

THERMAL ENERGY ENGINEERING

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Thesis Acceptance Certificate

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Abstract

The industrial sector of Pakistan is the largest consumer of energy and accounts for 37% of the total energy consumed in the country. The sector is witnessing a growing demand for energy which is expected to accelerate even further due to the expanded industrial activity under China Pakistan Economic Corridor (CPEC) project. Moreover, circular debt in the power sector, the weak financial condition of energy firms, high dependency on fossil fuel imports (85% of crude oil and POL demand) and decline in domestic gas output aggravates the energy problem. Several studies have found that increased energy generation is not the only way to solve such issues; effective energy management is also important for sustainable development. Pakistan is one of those countries that still lack a standardized management framework for energy. The aim of this study was to evaluate the level of implementation of energy management practices, barriers that hinder energy efficiency improvements, and drivers which boost the adoption of energy efficiency measures in the industry. The focus of this research is the Large-Scale Manufacturing (LSM) industries, the most important industrial sector of the country. A systematic survey was conducted in 90 LSM industries from 13 major industrial subsectors. Based on the minimum requirements outlined by the study, only 20% of industries were found to practicing energy management. Financial constraints, absence of incentives from the government, and lack of staff awareness were highlighted as the most notable barriers to energy management activities. The cost savings resulting from efficient use of energy and top management commitment were found as the greatest driving forces for industrial energy efficiency improvement. The findings of this would be useful to business decision-makers and government policymakers.

Keywords: Energy Management, Energy Consumption, Industrial Energy Efficiency, Energy Systems, Barriers, Drivers, ISO 50001

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List of Abbreviations

LSM – Large Scale Manufacturing

EnMS – Energy Management System

ISO – International Organization for Standardization

CPEC – China Pakistan Economic Corridor

UNIDO – United Nations Industrial Development Organization

NEECA – National Energy Efficiency and Conservation Authority

PDCA – Plan Do Check Act

KPI – Key Performance Indicator

List of Publications

1. **Muhammad Muneeb Ahmad**, Muhammad Bilal Sajid, Akhtar Abbas, Muhammad Kamran "Energy Management Practices in the Large-Scale Manufacturing (LSM) Industries of Pakistan; A Case Study" 3rd International Conference on Sustainable Energy Technologies (ICSET 2021), UET Peshawar. **(Presented)**

Chapter 1: Introduction

Energy management is the combination of energy efficient practices, strategies and associated procedures that result in reduced energy costs and emissions of CO_2 [1]. Managing energy consumption in the industries is critical for energy cost savings and long-term competitiveness, but its ability is underutilized due to several barriers. Earlier literature has pointed out that energy management can contribute significantly to the sustainable growth of manufacturing sector [2]. It is therefore important to evaluate the status of energy management practices in this sector and identify those factors which hinder or drive these practices i.e., barriers and drivers. Growing energy demand, rising energy prices and climate change have compelled governments and organizations to take immediate and effective actions to solve these issues. Energy efficiency and conservation is one of the most effective strategies to handle these problems. Like other governments of the world, Government of Pakistan is also taking necessary steps in this regard. The National Energy Efficiency and Conservation Authority (NEECA) plans to save 1.3 MTOE in the industrial sector under its five years Strategic Plan 2020-2025 [3]. The industrial sector of Pakistan is highly energy intensive with an energy intensity of 0.117 kgoe/$GDP vs 0.08 kgoe/$GDP in Europe [4]. The "Sustainable Energy for All (SEfor All) – National Action Plan" has a target to double the energy efficiency by 2020. To achieve this target, an annual reduction of 3.4% in the energy intensity is required. Hence, it is vital to efficiently manage the energy consumption of Large-Scale Manufacturing (LSM) industries, since they have the largest share in the total energy consumption of the country. In this study, an assessment of the energy management practices in the Large-Scale Manufacturing (LSM) industries of Pakistan and identification of major barriers and drivers for industrial energy efficiency has been done. A survey of 91 industries from 13 major manufacturing sectors was conducted. The aim of this study is to provide policy makers with useful insights and policy recommendations for the accelerated progress of energy efficiency programs.

1.1 Overview of Large-Scale Manufacturing Industries in Pakistan

The manufacturing sector of Pakistan is a major driver of economic growth due to its linkages with many other sectors. In 2019-20, it has contributed a share of around 14 percent in the GDP and provided employment to about 16.1 percent of the total labor force of the country [5]. The large scale manufacturing (LSM) industries represents 78% of the manufacturing sector and has 8% share in the GDP [5]. Energy consumption in the industry is approximately 38% of the overall energy consumption in Pakistan [6].

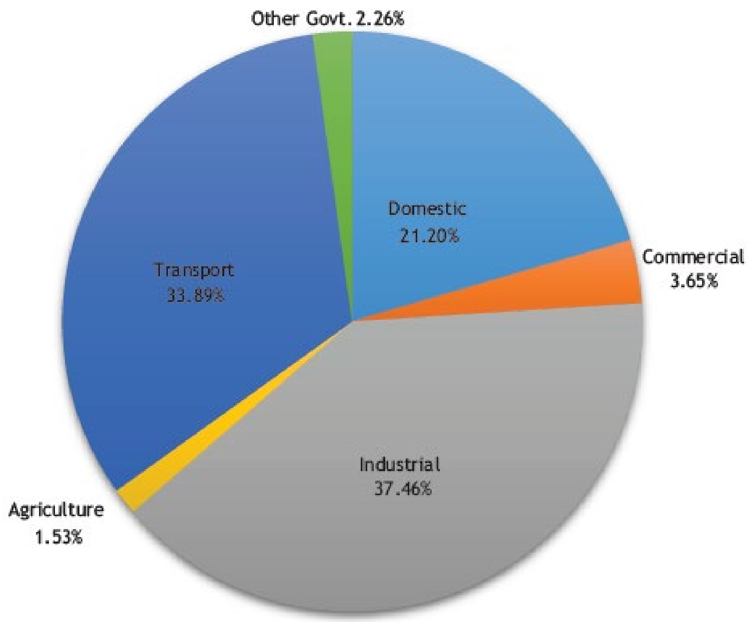

Figure 1.1 Sectoral Breakdown of Energy Consumption in Pakistan [2]

The sector consumes 29% of the total electricity generated in the country, while has the second largest share of natural gas consumption with 36 % [6]. In Fig 2,five years breakdown of energy consumption by fuel share is presented for the industrial sector. Coal and natural gas are the main energy sources for industrial sector accounting for approximately 80% of the total industrial energy consumed.

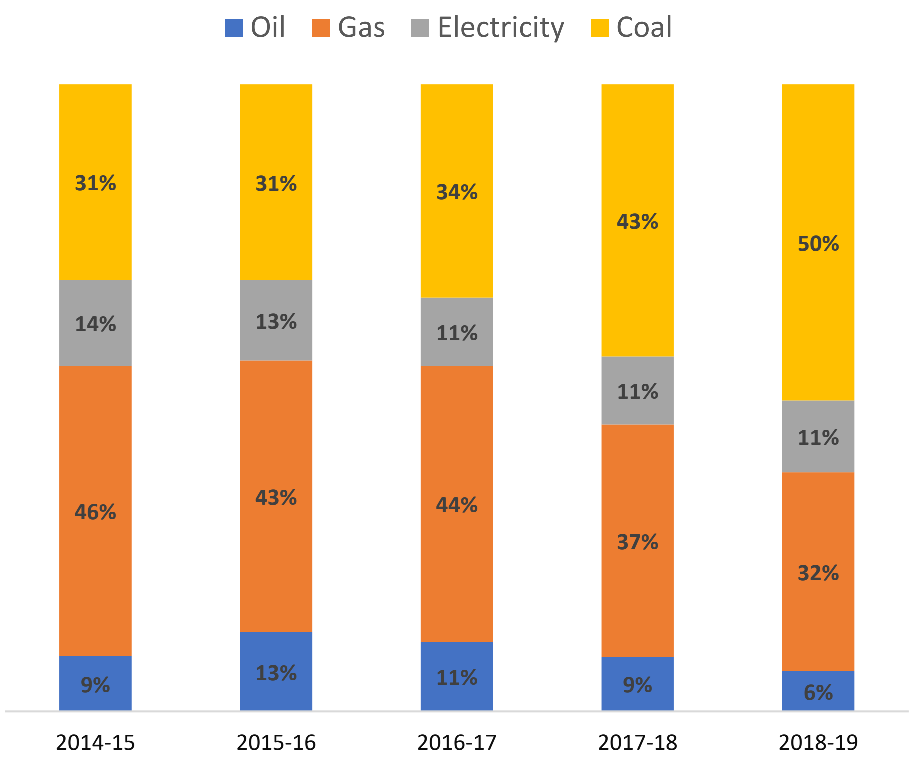

Figure 1.2 Breakdown of Industrial Sector Fuel Shares 2014-2019 [2]

Textile industry is the largest and most important manufacturing subsector of Pakistan. It employees 40% of the industrial labor [5] and comprises of 46% of the total manufacturing sector [7]. It contributes 60% share in the country's export. Textile industry consumers 27.6 % of the total industrial electricity consumption [3]. Food, beverages, and tobacco industry is the second most important sector. It contributes 27% share in the value added production and provides employment to 16% of the total m [8]. The fertilizers industry is the largest consumer of natural gas and accounts for 50% of the industrial natural gas consumption. The cement sector is the biggest coal consumer with 53% share in the total coal consumption of Pakistan [6]. Iron & steel, automotive, petroleum products and paper and paper board are also considered as important subsectors of large-scale manufacturing (LSM) industries. An estimated savings of 1.25 Billion USD per year can be achieved through proper management of industrial energy consumption [9]. According to a report of National Productivity Organization (NPO), textile sector only has a potential of saving 2.4 Million MWh of energy annually, but it is unknown that how many mills implement the energy saving measures [10].

1.2 Problem Statement

The industrial sector of Pakistan is the largest consumer of energy resources in the country. The energy demand is increasing in this sector, and it is projected to grow even further as China-Pakistan Economic Corridor (CPEC) expands its activity. However, the country's high dependency on imported fuels, rise in energy prices, and environmental issues pose a threat to industrial growth. In this scenario, effective management of energy consumption is vital for sustainable development. The Large-Scale Manufacturing (LSM) industries are the biggest stakeholders in the industrial sector of Pakistan. The aim of this study was to assess the degree to which energy management practices are being implemented in LSM industries, the challenges that are preventing energy efficiency improvements, and the factors that encourage the introduction of energy efficiency initiatives in the industry.

1.3 Literature Gap

The subject of industrial energy management is not much explored in the context of Pakistan as compared to other countries, especially the developed ones. Very few studies are available considering energy management practices in the Pakistani industries. Iftikhar et al. [11] conducted a survey in the iron and steel industry of Pakistan to assess major barriers and drivers of energy efficiency in this sector. In 2014, Nadeem et al. [12] also done a questionnaire based study in the selected government organizations, industries and academic institutes of Pakistan to investigate hurdles in the improvement of energy efficiency. Hassan et al. [13] have performed a survey on the obstacles to energy-efficient activities in the Small and Medium Enterprises (SME) of Pakistan. The constraints were investigated in relation to the scale of the businesses, the competence of the energy managers, and the size of the businesses. However, no study has been found in the literature which evaluated the current level of energy management practices in the Large-Scale Manufacturing (LSM) industries of Pakistan and investigated the barriers and drivers of effective energy management . Through a systematic questionnaire-based study of 90 LSM industries belonging to 13 major sectors, this work aims to fill this research gap.

1.4 Research Outcomes

The outcomes of this study are:

1. Assessment of the status of energy management practices in LSM industries based on a systematic and proven framework.
2. Identification of major barriers to energy efficiency improvement in LSM industries
3. Identification of main drivers of energy efficiency improvement in LSM industries

Summary

This Chapter introduces the key concepts of this study. The importance of energy management is established. In the following section, an overview of the Large-Scale Manufacturing (LSM) industries is provided with focus on energy consumption in this sector. In the third section, problem statement, expressing the motivation to undertake this work is provided. The second last section discussed the literature gap and need of the current study. In the last, research outcomes are stated.

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Chapter 2 : Literature Review

2.1 Industrial Energy Management

The process of monitoring and optimizing energy consumption of an industry is known as industrial energy management. In a company, energy management entails the introduction of energy-efficient technologies along the application of procedures and policies to assure the maximum utilization of these technologies [1]. According to the definition of Challagan and Probet [2] "Energy management applies to resources as well as to the supply, conversion and utilization of energy. Essentially it involves monitoring, measuring, recording, analyzing, critically examining, controlling and redirecting energy and material flows through systems so that least power is expended to achieve worthwhile aims."

Growing demand of energy, unstable and rising energy prices and environmental issues present the biggest challenges faced by the industrial sector. Energy management is a sustainable and effective solution to all these problems. Previous studies show that companies adopting energy management were able to improve their energy performance up to 40% [3]. Efficient use of energy in the industry is considered as one of the most effective solutions to reduce greenhouse gas (GHG) emissions and slow down climate change [4].

2.2 Energy Management System and Minimum Requirements

A structured energy management system (EnMS) is a proven method for implementing energy management within an organization. According to the definition of International Organization of Standardization (ISO) , an EnMS is "set of interrelated or interacting elements to establish an energy policy and energy objectives, and processes and procedures to achieve those objectives" [5]. It is a holistic approach combining technical tools and managerial skills for the improvement of energy performance of a company.

Many studies in the past focused on defining a set of minimum requirements for the implementation of energy management. Based on the research of Schulze et al. [6], table below illustrates a set of minimum requirements for energy management and their level of consideration in the past studies.

Table 1.1- Minimum requirements for energy management implementation

Minimum Requirements	**Christoff-ersen et al., 2006** [7]	**McKane et al., 2007** [8]	**Tholland-er & Ottosson 2010** [9]	**Abdelazi-z et al., 2011** [10]	**Ates & Durakbasa, 2012** [11]
Develop long term energy plan and establish energy policy	◐	◐	●	●	◐
Assigns roles and duties to organize energy management activities	◐	○	○	◐	○
Formation of cross disciplinary energy teams lead by an Energy Manager	○	●	○	●	◐
Establish applicable policies and procedures, such as those governing energy efficient procurement, energy consideration in design etc.	◐	●	○	○	◐
Conduct energy audits to identify energy saving opportunities	○	○	●	●	○
Plan energy efficiency projects to achieve energy targets and realize energy saving opportunities	●	●	●	◐	●

Identify key performance indicators for that are specific to the organization and are monitored on a regular basis to assess improvement in energy performance	○	●	○	○	○
Regularly measure and track the energy use of key manufacturing processes	○	○	●	◐	◐
Management should review the energy performance on periodic basis	○	●	○	●	○
Active support of top management	○	○	●	○	○
Train and motivate the staff for active energy management	◐	○	◐	◐	◐

Legend:

● Fully Consider, ◐ Partially Consider, ○ Not Considered

2.3 Energy Management Standards

An energy management standard advises manufacturing facilities on how to incorporate energy efficiency and conservation practices into their management procedures, such as monitoring their production processes and optimizing them to maximize energy savings [8]. Several energy management standards have been developed by different countries and organizations to help industries in managing their energy consumption in a systematic way. The European Union countries had EN 16001 standards for energy management [12],China developed GBT/T23331 standard in 2009 [13]. Similarly US Environmental Protection Agency (USEPA), introduced ENERGY STAR program [14] for industry. In 2011, ISO 50001 [15], was published by International Organization for Standardization (ISO) as a global standard for energy management. Since its publication, it has replaced many local energy management standards. According to a survey by ISO in 2019, more than 42000 industries around the world has adopted this standard for better management of energy [16].

2.4 Barriers to Industrial Energy Efficiency Improvement

The disparity between what is perceived to be the optimal level of energy efficiency and the actual implementation of energy efficiency is known as ‘‘energy efficiency gap" [17]. The existence of an energy efficiency gap confirms the presence of barriers to energy efficiency. According to the definition of Sorrel [18], a barrier is a mechanism that appears to suppress a decision or behavior that appears to be both energy and economically efficient. All those factors which hamper the adoption of economically viable energy efficient technologies and slow there diffusion in the market can be considered as barriers to energy efficiency [19].

The study of barriers is a multidisciplinary field and includes technological, economical, behavioral, organizational and management aspects which hinder the adoption of energy efficiency practices [20]. Due to the broad nature of this subject, different classifications of barriers are available in the literature. Thollander et al. [21] divided barriers into three categories namely Economic, Organizational and Behavioral barriers. Another definition can be found in the Intergovernmental Panel on Climate Change (IPCC) Third Assessment Paper [22], which conducted an exhaustive analysis of the current literature for the obstacles to greenhouse gas (GHG) emissions mitigation through industrial energy efficiency . The IPCC has identified eight sources of sector and technology-specific obstacles in this study: (i) technological innovation, (ii) prices, (iii) financing, (iv) trade and environment, (v) market structure and functioning, (vi) institutional frameworks, (vii) information provision, and (viii) social, cultural, and behavioral norms and aspirations. Cagno and Worrel [4] divided barriers to energy efficiency into seven groups. They categorized them into (i) economic; (ii) information-related; (iii) organizational;(iv) behavioral; (v) competence-related; (vi) technology-related; and (vii) awareness. In this study this categorization has been adopted for analysis of energy efficiency barriers in the industrial sector of Pakistan

The economic or finance related barriers are considered one of the greatest obstacles in the adoption of energy efficiency technologies and practices. A survey conducted in the textile sector of Bangladesh points out that inadequate capital is the biggest hurdle in industrial energy efficiency [23]. Rohdin et al. [24] conducted a study in 30 Swedish foundries and found that limited access to capital is key reason for no up taking efficiency related projects. Similarly, a survey of 128 manufacturing companies in Italy ranked lack of devoted capital for energy efficiency investment as the most important barrier [25].

Information related barriers include lack of adequate knowledge or skills for energy management, lack of information on cost and benefits of energy efficiency, trustworthiness of information sources etc. De Groot et al. [26] performed a survey of Dutch businesses and discovered that 30% of the respondents were unaware, or only vaguely aware, of new or emerging energy-efficient innovations or practices.

Organizational barriers such as lack of time for energy management activities, strict payback criteria for efficiency related investments, insufficient management support, low status of energy efficiency etc. are also considered important barriers in the literature. A study of Swedish foundry industry reveals that group owned companies face organizational barrier as the biggest hurdle in making efficiency related decisions [24]. A survey of Chinese industries pointed that lack of management motivation and lower priority to energy efficiency are important barriers [27].

Cattaneo et al. [28] studied relation between energy efficiency and behavioral factors. Inadequacy of available technologies and risk associated with new energy efficiency solutions are considered as obstacles in the improvement of energy efficiency [29]. Awareness related barriers mainly include lack of staff knowledge and interest in improving energy efficiency at the organization [25],[17].

2.5 Drivers for Industrial Energy Efficiency Improvement

The factors that can overcome the barriers to energy efficiency and accelerate the uptake of energy efficient technologies and practices are known as drivers of energy efficiency [30]. Like categorization of barriers to energy efficiency, driving forces for efficiency improvement have also been categorized into different groups. Thollander et al. [31] classified them into four categories: financial, informational, organizational and external driving forces.

Financial drivers for energy efficiency include Energy taxation including Sulphur, NOx, and CO2 taxes, rising energy costs, cost savings from reduced energy consumption, loans for energy efficiency investments, subsidies for energy efficiency investments. Financial drivers are considered the most important factor in the improvement of industrial efficiency. In a survey based study of the foundry sector in Germany, Italy, Spain and Poland; respondents ranked finance as the most important driving force to adopt energy efficiency [31]. Cost reductions resulting from efficient energy use is considered top driver of energy efficiency in studies conducted in Ghana and Bangladesh and India [20] [32] [17].

Information related drivers comprise support from government and private authorities in the form of consultancy, access to energy efficiency literature, conduct of seminars related to energy efficiency, information of relevant technologies etc. In a study of 71 Italian firms [33], access to energy efficiency experts is considered as an important driver.

Top management commitment improved environmental profile of the organization and long-term energy strategy are some of the examples of organizational driving forces for energy efficiency. A questionnaire-based study in the cement and lime sector of Belgium [34] considered top management commitment as an important driver of energy efficiency. In several studies, Long term energy strategy and improved environmental reputation of the organization are ranked as significant driving forces to improve energy efficiency [24],[20],[35].

External drivers of energy efficiency include regulations from the government such as national standard for energy management, demands from customers, pressure from environmental NGOs etc. Cagno et al. [33] found that external pressures can be considered as driving force in the improvement of industrial energy efficiency.

Summary

This chapter discusses the literature review done by the author. The concept of industrial energy management is explained, and definitions were quoted from the literature. In the second section, the energy management systems and minimum requirement for their implementation are discussed. Following this a brief overview of energy management standards is provided. The last two sections explain the terms “barriers” and “drivers” for industrial energy efficiency with the help of previous research.

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Chapter 3 : Methodology

3.1 The Context of Investigation

The research has focused on the Large-Scale Manufacturing (LSM) industries of Pakistan to find out the answers to following three research questions:

1. What is the status of energy management practices in the LSM industrial sector of Pakistan?
2. What are the main barriers to energy efficiency and conservation practices in industry?
3. What are the important drivers which can improve the energy management in the national industrial sector?

3.2 Research Method

To address the research questions, a survey-based approach was adopted. This type of research method is classified as empirical research [1] since the data is directly gathered from the subject of study which in this case are industries in Pakistan. The questionnaire is developed based on the literature as well as similar research in the area. Questionnaire based research method has been previously used in several similar studies in different regions of world. Ates and Durkbasa [2] conducted a questionnaire based study to evaluate corporate energy management practices in the energy intensive industry of Turkey. Bojana et al. [3] investigated the status of energy management system application through industrial surveys. Lawrence et al. [4] assessed barriers and drivers for energy management improvement in Swedish pulp and paper industry. Hasan et al. [5] studied barriers and driving forces for efficient energy practices in manufacturing sector of Bangladesh through questionnaires. A very comprehensive study was carried out under United Nations Development Organization (UNIDO) by Sorrel [1] reviewing the literature on the surveys conducted in Germany, China, Greece, Thailand, Sweden and Ireland to investigate industrial efficiency barriers.

The study is carried out using an online questionnaire. The questionnaire was divided into 5 sections:

1. Respondent information
2. Industry information
3. Energy management practices at the industry
4. Drivers of energy management practices
5. Barriers to energy management practices

The focus of this study is the Large-Scale Manufacturing (LSM) industries of Pakistan. Economic Survey of Pakistan 2019-20 [6] is used to select thirteen manufacturing sectors having largest share in the economy. The questionnaire was sent via email, telephone, and professional network LinkedIn.760 industries were contacted, and the survey response rate was 11.8%.

3.3 Surveyed Industrial Sectors

A total of 90 industries from 13 sectors respondent to the survey. The food, beverages and tobacco sector were the largest participants with 19 industries while textile and Apparel sector has the 2nd largest share of 15 industries in this study.

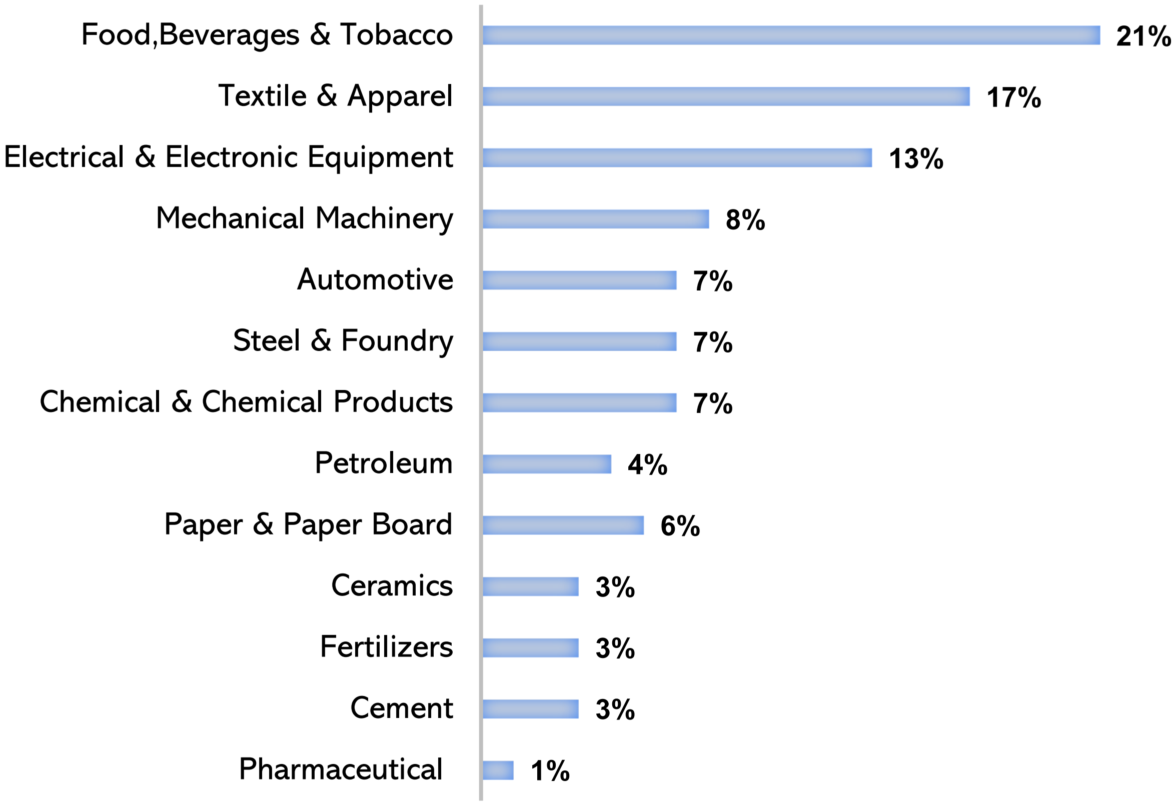

Figure 3.1 Sector wise breakdown of participated industries

3.4 Demographic Characteristics

66 percent of the respondent firms are from Punjab province. The industries from Sindh province have a share of 22%. The Baluchistan province had the lowest number of industries participated in this study.

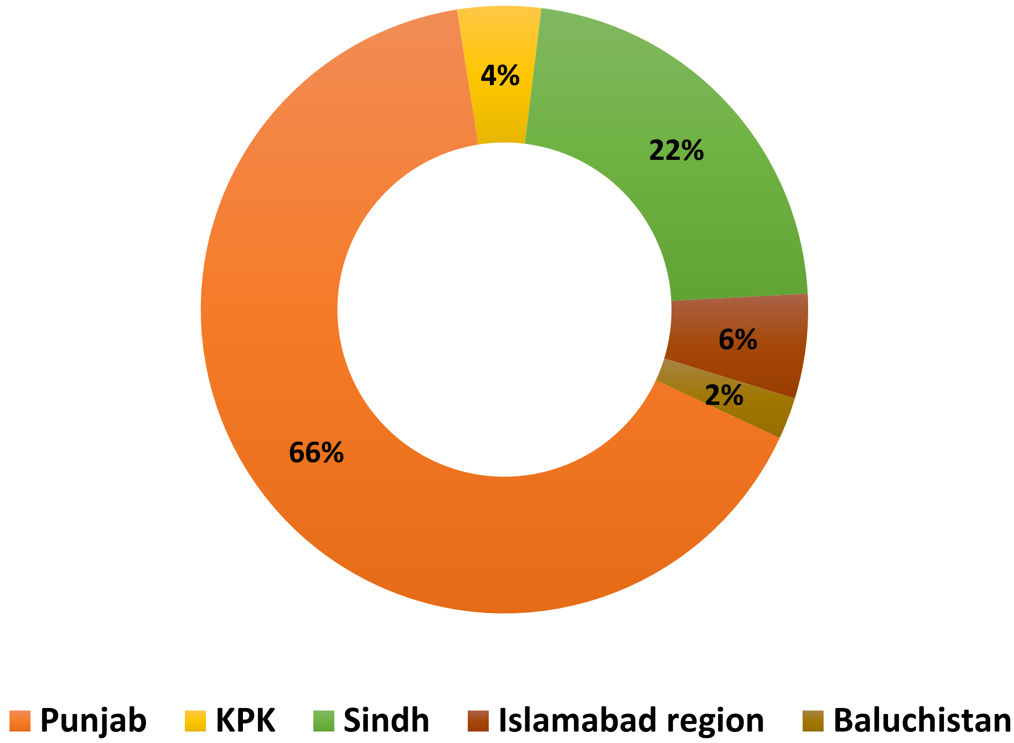

Figure 3.2 Regional distribution of participant industries

3.5 Size of participants industries

The number of employees is used to categorize the industries into large, medium, and small firms. The respondents were asked to select number of employees in their firm from three options (more than 100 employees, 51-100, less than 50 employees). 79 out of 90 participant industries had more than 100 employees which is 88% of the total respondents.

3.6 Respondent's Information

The respondents were asked to tell their department and position in the management chain. 79 % of the respondents belong to maintenance and production departments since they were mostly involved in energy consumption and management related activities. In the survey participants, only one textile company has dedicated energy management department.

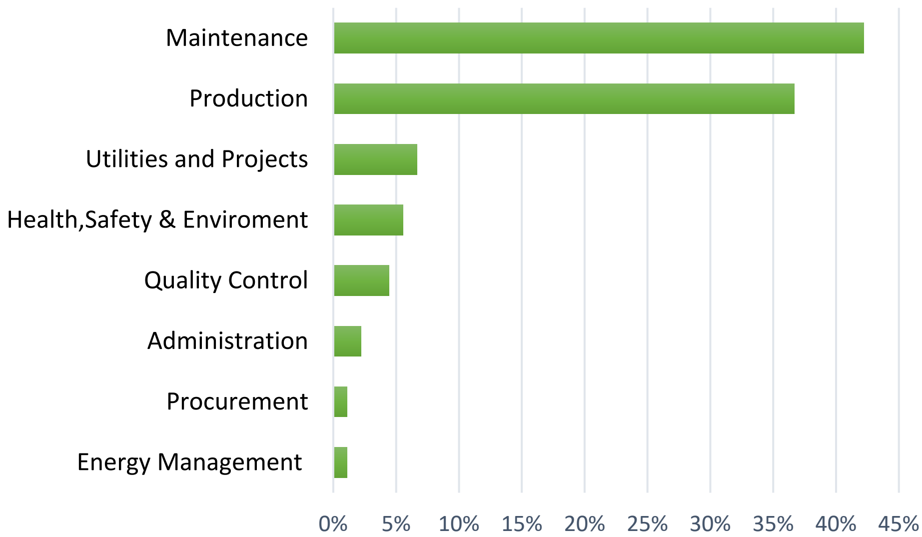

Figure 3.3 Respondents Departments

Majority of the respondents belong to middle level management (73 percent). Only 6% of the participants were from top level management.

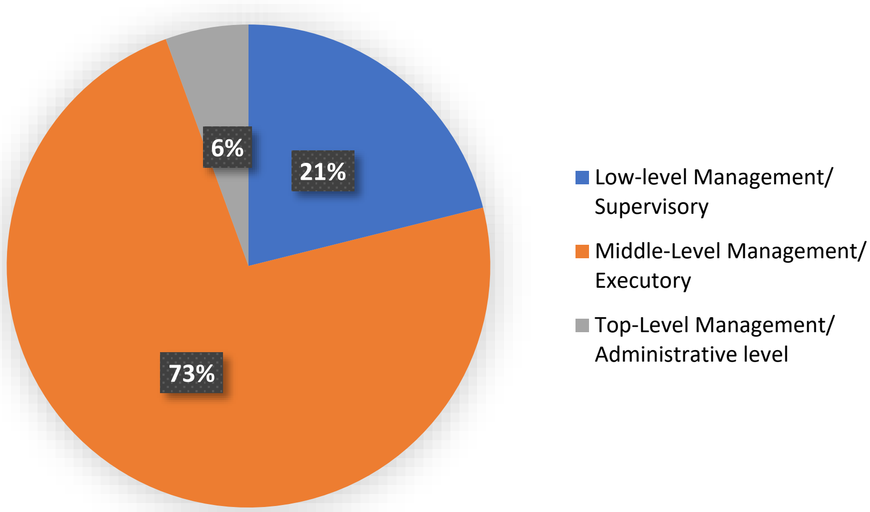

Figure 3.4 Respondents Position

3.7 Previously Implemented Management Systems

A management system is a compilation of rules, protocols, and practices that an organization implements to ensure that it can accomplish the tasks necessary to meet its goals [7] . The implementation of a management system shows that the firm has the capability of adopting policies and procedures for improvement of its performance. The respondents provided information of all the management systems adopted by their firm. This was asked to investigate the participants understanding of management concepts and capability of implementing energy management system. 78 out of 90 industries had certification of ISO 9001 (Quality Management System). This is 86 % of the total participant industries.48% of the firms also had certification of ISO 14001 (Environment Management System). Only 8 firms did not have any certification regarding management system.

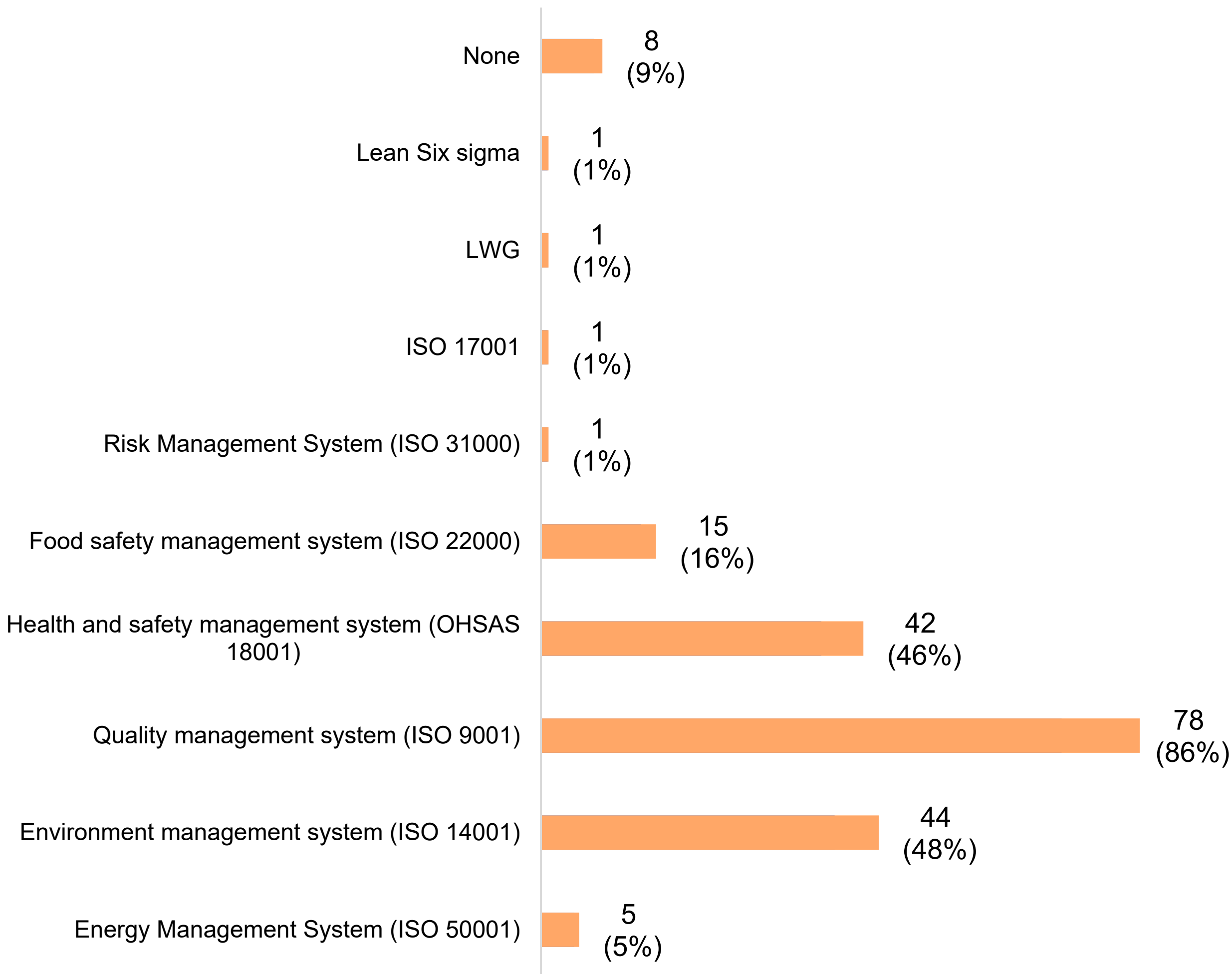

Figure 3.5 Implemented management systems at the participant industries.

3.8 Assessment of the status of Energy Management Practices

Surveyed industries are asked ten close ended questions and the respondents had to answer with either "YES" or "NO" to each question. The questions are based on the PDCA framework of energy management.

3.8.1 The PDCA Cycle

To investigate the status of energy management practices in the industries of Pakistan, an analytical framework based on the Deming's Plan Do Check Act (PDCA) management model [8] has been adopted. This model forms the basis of several management systems including the ISO 50001 Energy Management Standard published by International Organization of Standardization in 2011 [9]. The management model works on the continual improvement framework and requires an organization to continuously monitor and improve its energy performance.

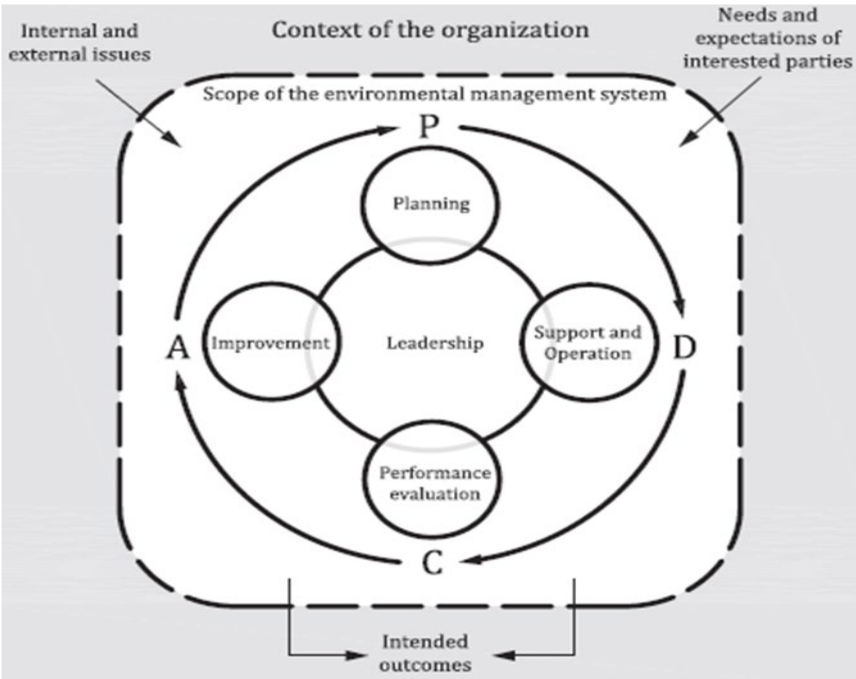

Figure 3.6 PDCA Cycle for Energy Management [9]

There are 4 pillars of the PDCA approach [3] :

Plan: To manage energy efficiently, an organization must prepare a plan on how it will be going to manage its energy consumption. This includes devising an energy policy, appointing energy managers, defining energy performance indicators or energy KPI's to monitor energy usage and having a documented procedure for energy planning.

Do: The "Do" part of PDCA cycle deals with the implementation of energy planning process. The practical steps taken by the management such as conduct of energy audits, procurement of energy efficient equipment, trainings of staff etc. are included in this stage.

Check: Periodically checking the results of energy management actions and search for non-conformities are included in this step. The management must review the energy performance of the organization and ensure that the objectives and targets set by them are met.

Act: To ensure continuous improvement in the energy performance, suitable actions are required to rectify any non-conformities found in the energy management process.

3.8.2 Minimum Requirements List for Energy Management

In this study, following energy management practices are taken as minimum requirements for energy management based on the research of Christoffersen (2006) [10], Ates (2012) [2] and ISO 50001:2018 [9] which is the latest energy management standard published by International Organization of Standardization:

1. Presence of a formal energy policy
2. Having an energy manager
3. Having documented process of energy planning
4. Energy Performance Indicators (KPI's) are defined.
5. Submetering is done to record energy consumption at the process level/machinery.

6. Energy audits have been performed in the past.
7. Energy efficiency is considered in the design of the site/new projects.
8. Trainings related to energy efficiency and management are conducted for the staff.
9. The procurement of products, services, and equipment are evaluated based on energy efficiency.
10. Top management regularly reviews the energy performance of the organization.

Based on the responses, the surveyed industries are divided into two categories; companies practicing energy management and companies which are not practicing energy management. The results are presented in the results and discussion chapter.

3.9 Assessment of Barriers to and Drivers for Energy Efficiency

In the 4th and 5th sections of the questionnaire, using a 5-point Likert scale, research participants were asked to rate barriers and drivers of industrial energy efficiency. There were five options, and the respondents rate the drivers and barriers from "Not Important" to "Very Important". The survey participants were asked to mark the significance of following ten barriers to industrial energy efficiency improvement:

1. Financial constraints (Limited access to dedicated capital for energy efficiency related projects)
2. Absence of incentives (e.g., tax exemption, subsidies) from the government
3. Lack of staff awareness regarding energy conservation
4. Longer payback periods for energy efficiency related projects
5. Unavailability of energy management experts in the local market
6. Lack of technical skills regarding energy management
7. Lack of time for energy management related activities
8. Technical risks in the adoption of energy efficiency measures
9. Insufficient support from top management
10. Unavailability of cost-effective energy efficiency solutions

The survey included eight drivers for the examination of significant factors for energy efficiency improvements, and participants were asked to grade each driver from “not important” to “very important”. The following are the drivers presented for ranking:

1. Cost saving resulting from efficient energy use.
2. Commitment from top management
3. Subsidies for the purchase of energy efficient equipment
4. Tax incentives from government
5. The improved environmental reputation of the organization
6. Laws and regulations related to environment and energy efficiency (e.g., National Energy Efficiency and Conservation Act 2016, Environmental Protection Laws)
7. Free of cost consultation from international and local authorities (e.g., UNIDO, NEECA, PEECA)
8. Pressure from customers and NGOs

3.9.1. Categorization of Barriers

Since the study is empirical in nature, a theoretical framework based on the works of Cagno and Worrel [11] and Sorrel [1] was adopted. The barriers asked in this study were categorized according to their nature (theoretical background), e.g., economic, technological, regulatory barriers etc. The table below provides a description of the categories in which barriers were divided:

Table 3.1 Categorization of barriers to energy management

Theoretical Category	Barriers
Economic	Access to capital for energy efficiency related projects
Regulatory	Absence of incentives from government to support energy management activities
Awareness	Lack of staff awareness leading to energy loss
Risk	Technological risks such as production failures arising from adopting new energy efficient technologies, financial risks involved with long payback periods

Technology/ Services provisions	Unavailability of cost- effective energy efficiency solutions, Unavailability of energy management experts in local market
Organizational	Insufficient support from top management, lack of time for energy management activities
Information	Lack of technical skills regarding energy management

3.9.2 Categorization of Drivers

The drivers for energy management are categorized based on their origin or action required -i.e., whether it is a policy related to (i) Finance, (ii) Regulation, (iii) Information or (iv) Organization. This categorization concept is based on the research of Thollander et al, [12]. Table 2 provides the categorization of studied drivers.

Table 3.2 Categorization of drivers of energy management

Theoretical Category	Driver
Finance	Cost saving resulting from efficient energy use, Subsidies for the purchase of energy efficient equipment, Tax incentives from government
Regulation	Laws and regulations related to environment and energy efficiency
Information	Free of cost consultation from international and local authorities
Organization	Commitment from top management, improved environmental reputation of the organization

3.10 Statistical Analysis

To rank the barriers and drivers for energy management, method of weighted average was adopted. The 5 options on the Likert scale are ranked as follows:

Not Important = 0

Slightly Important = 1

Moderately Important = 2

Important = 3

Very Important = 4

The average score for each barrier and driver for all the 90 participant industries was collected based on which ranking of most important barriers and drivers was performed. Before ranking the survey items, Cronbach's alpha test was performed for the set of barriers and drivers separately. This statistical test is used to assess the reliability and inter consistency of the survey items [13]. The degree to which an instrument can provide the same results if the test is repeated under the same conditions is referred to as reliability or consistency. It shows that the set of questions point towards a single construct or subject [14]. The Cronbach's Alpha value of 0.7 or above is considered acceptable [15].

Summary

This chapter details the methodology adopted for this research work. The questionnaire-based research method is discussed in detail. The background information on surveyed industries is provided in this chapter. Then the methodology acquired to investigate the status of energy management practices, significance of barriers to and drivers for energy efficiency is explained. The data analysis techniques used to interpret the results are described in the last section of the chapter.

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Chapter 4: Results and Discussion

4.1 Status of Energy Management in the LSM Industries of Pakistan

The first section of the questionnaire investigates the level of adoption of energy management practices by the LSM industries of Pakistan. As discussed in the methodology chapter, these questions were based on the PDCA management model [1]. This model has been used as the analytical frame work of many management systems including the ISO 50001 Energy Management Standard published by International Organization of Standardization in 2011 [2]. Surveyed industries are asked ten close ended questions and the respondents had to answer with either "YES" or "NO" to each question.

4.2 Energy Planning in the industries

For the assessment of the energy planning in the industries of Pakistan, following four questions were asked:

1. There is a formal Energy Policy of the industry?
2. Energy Manager has been appointed to monitor energy performance?
3. There is a documented process of energy planning in order to improve energy performance.
4. Energy Performance Indicators (KPI's) to gauge energy performance are defined?

4.2.1 Energy Policy

Energy policy is the first evidence of top management's commitment towards managing the organization's energy performance. The objectives outlined in the policy define the path for future energy management activities. The survey results show that 53% of the industries have a formal energy policy.

4.2.2 Documentation of Energy Planning

Presence of a documented process for energy planning shows top management's seriousness in managing the energy at the industry. 56% of the surveyed industries said they have a documented procedure for energy planning.

4.2.3 Energy Performance Indicators (KPI's)

Energy performance indicators or energy KPI's are the pointers of energy performance of an organization. They help industries to gauge the output of their energy management efforts. They can be a simple ratio like energy intensity or complex regression-based analysis matrix.54 out of 90 industries use Energy Performance Indicators or Energy KPI's to gauge their energy performance. This accounts around 66% of the surveyed population.

4.2.4 Appointment of Energy Managers

39 percent of the surveyed industries has appointed energy managers to monitor energy performance. However dedicated energy managers are not common in Pakistan and generally this is an additional responsibility of production or maintenance managers. The role of energy manager is very important for the implementation of energy management projects. He is responsible for monitoring energy consumption and tracking company's progress towards their energy saving goals.

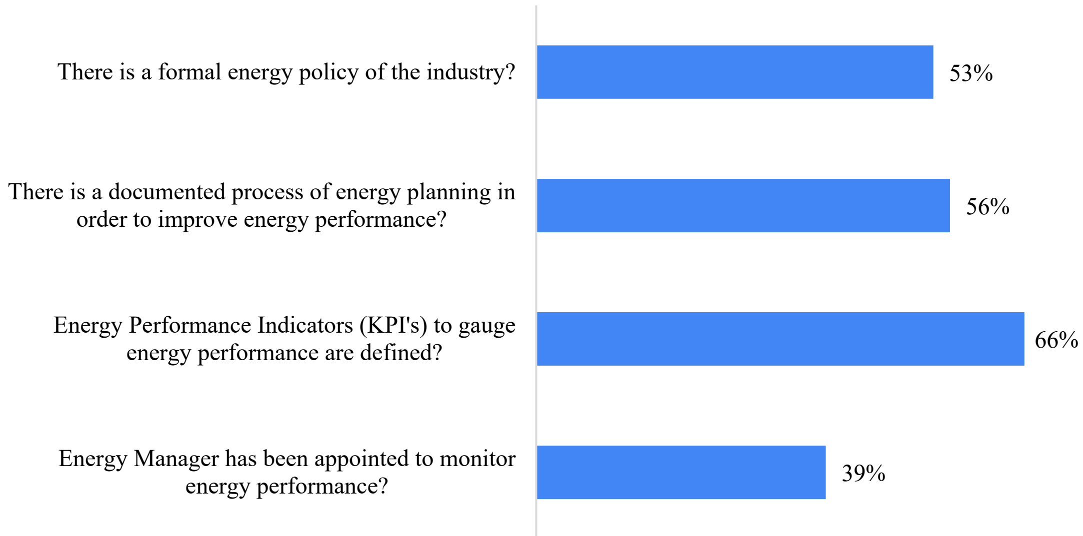

Figure 4.1 Energy Planning in Industries

4.3 Implementation and Monitoring (Do & Check Phase)

The implementation of energy management practices belongs to the "Do" phase of PDCA cycle while monitoring of these activities refers to the "Check" phase of the cycle. To assess the implementation and monitoring of energy management practices, industries have been asked the following five questions:

1. Submetering is done to record energy consumption at the process level/machinery?
2. Energy audits have been performed in the past?
3. Energy efficiency is considered in the design of the site/new projects?
4. Trainings related to energy efficiency and management are conducted for the staff?
5. The procurement of products, services, and equipment are evaluated based on energy efficiency?

4.3.1 Submetering to Record Energy Consumption

66% of industries record their energy consumption at process and machinery level and has submetering for this purpose. Data is the key for better energy management and submetering provides this data for analysis.

4.3.2. Conduct of Energy Audits:

Energy audits have been performed in the past in 68 percent of the surveyed industries. Energy audits are performed to assess the energy performance of the system and to find out the energy saving opportunities.

4.3.3. Energy Efficiency Consideration in Design:

According to the survey results, 73% industries consider energy efficiency in the design of new site or project.

4.3.4. Staff Training on Energy Efficiency:

The trainings for the staff related to energy efficiency and management have been conducted in 46 percent of industries. Awareness of plant personnel regarding energy efficiency and conservation is critical for successful energy management.

4.3.5 Energy Efficient Procurement:

The survey results show that 70% industries evaluate procurement of products, services and equipment based on energy efficiency. This is an encouraging result showing industry's interest in improving their energy performance.

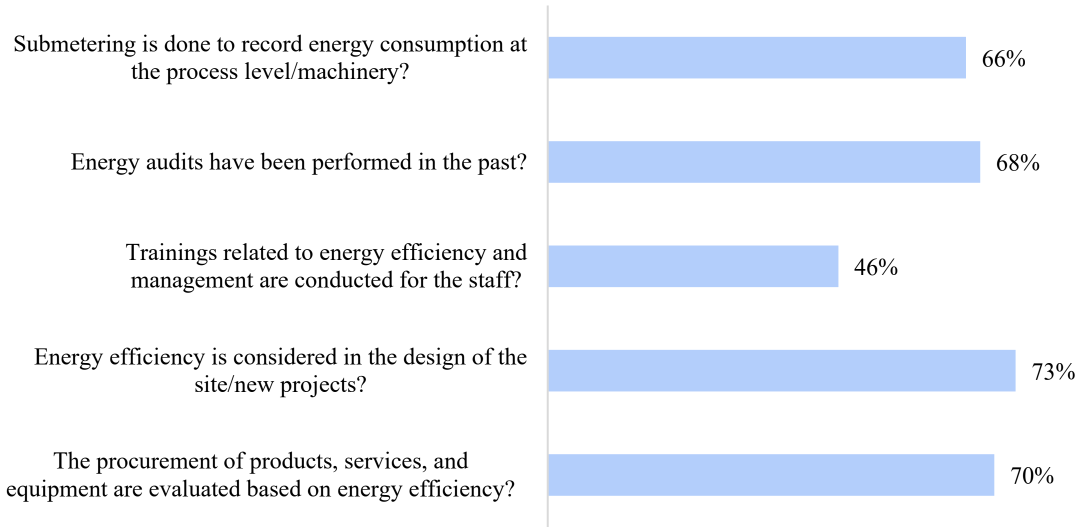

Figure 4.2 Energy Management in Industries: Do & Check Phase

4.4 Review of Energy Management Practices (Act Phase)

The top management is responsible for reviewing the energy management practices and take necessary actions to rectify non-conformities. The purpose of management review is to ensure the ongoing suitability, adequacy, and effectiveness of the energy management practices in terms of meeting requirements and generating the intended results. Based on their review of the status of the energy management and the resulting energy performance, top management decides what action is needed for continual improvement of energy performance. . The survey asked the industries to comment on whether the top management frequently reviews the energy performance of the organization and take actions to address the problems. It was found that in 66% industries, top management regularly reviews the energy performance of the industry.

4.5 Analytical Minimum Requirements for Energy Management

Energy management consists of several different elements; therefore, a methodology is required to find out whether a company practices energy management. Based on the research of Christoffersen (2006) [3], Ates (2012) [4] and ISO 50001:2018 [2] which is the latest energy management standard published by International Organization of Standardization, a set of minimum requirements has been developed. The studied companies are split into two categories based on this minimum requirement list: companies practicing energy management and companies not practicing. It must be considered that a different set of requirements may produce different results. In this study, following energy management practices are taken as minimum requirement:

1. Presence of a formal energy policy
2. Having an energy manager
3. Having documented process of energy planning
4. Energy Performance Indicators (KPI’s) are defined.
5. Submetering is done to record energy consumption at the process level/machinery.
6. Energy audits have been performed in the past.
7. Energy efficiency is considered in the design of the site/new projects.
8. Trainings related to energy efficiency and management are conducted for the staff.
9. The procurement of products, services, and equipment are evaluated based on energy efficiency.
10. Top management regularly reviews the energy performance of the organization.

Using the methodologies described above, it was discovered that only 20 percent of the surveyed companies practice energy management. Since 88% of the surveyed companies are large firms with more than 100 employees and high energy consumption it can be inferred that the rate of energy management is significantly below 20 percent for small Pakistani companies.

4.6 Awareness of ISO 50001 Energy Management Standard

ISO 50001 is a global standard for energy management that is both holistic and standardized. The International Organization for Standardization (ISO) first published it in 2011 and updated it in 2018. ISO 50001 was published with the aim of assisting organizations in continuously improving their energy efficiency through a comprehensive energy management mechanism. The specification outlines the criteria for an energy management system (EnMS) that allows any enterprise to enhance its energy efficiency more deeply and sustainably. According to the latest survey conducted by ISO in 2019, more than 42,000 facilities around the globe has implemented ISO 50001 standard at their site [5]. The survey also reveals that only 16 companies in Pakistan has obtained this certification which is very low as compared to the international uptake of this standard.

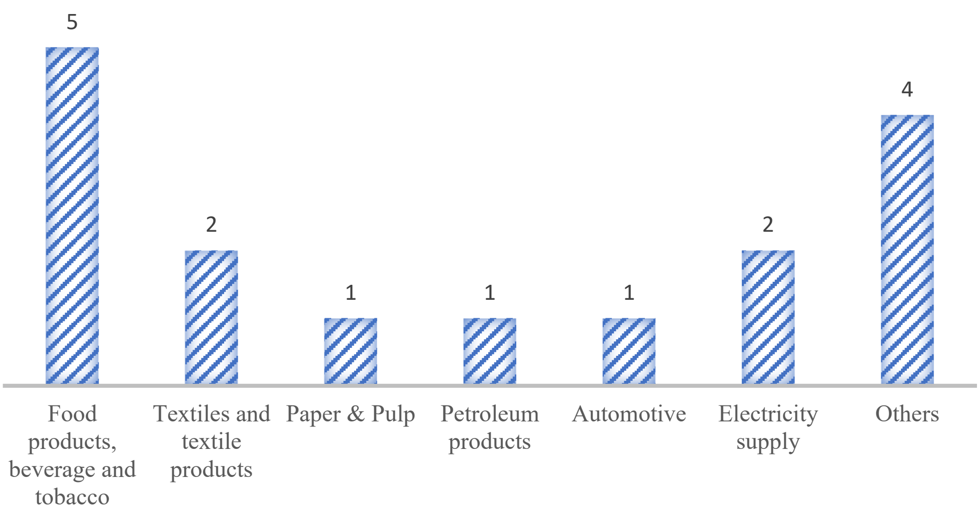

Figure 4.3 Sector Wise Number of ISO 50001 certifications in Pakistan (2019)

In this research, the participants were asked to mark their awareness level of the ISO 50001 standard. Only 20% of the participants from industries have the knowledge of this management system. 20 percent said that they are aware of it to some extent while 60% have no knowledge regarding this standard.

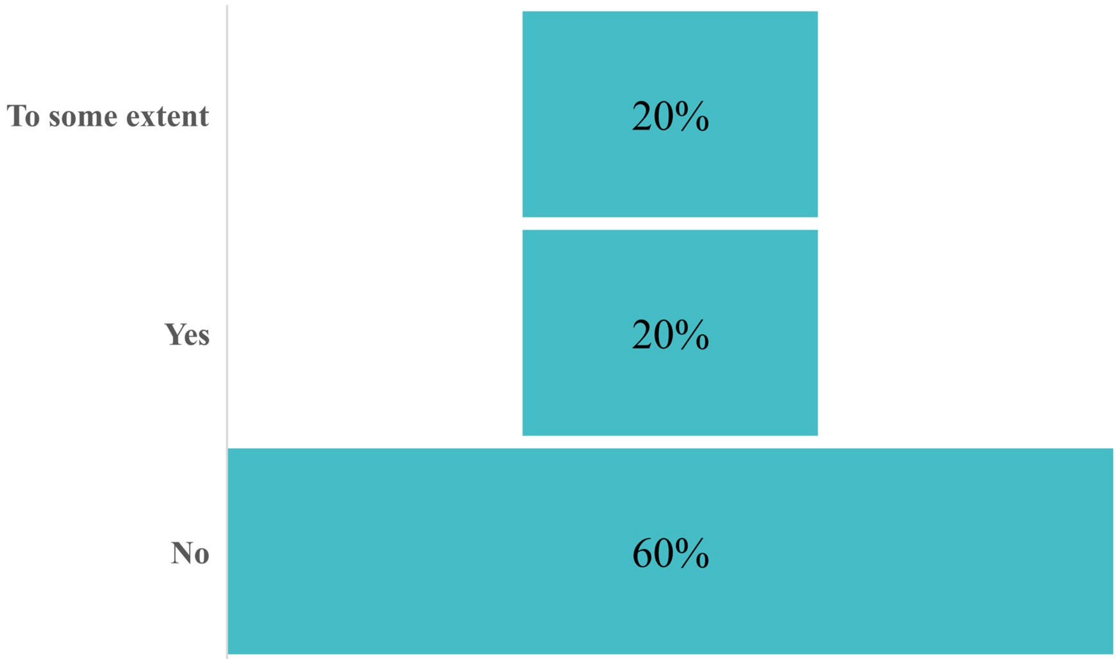

Figure 4.4 Awareness of EnMS ISO 50001

4.7 Barriers to Industrial Energy Efficiency Improvement

The first section of the survey assessed the status of energy management practices in the Pakistani industries. As a general perception and later confirmed by the survey results, there exists an efficiency gap resulting in insufficient energy management practices. The existence of this gap provides a strong rationale for the presence of barriers to energy efficiency.

To assess the obstacles in effective energy management, interviewees rated ten barriers to energy efficiency: using a scale 0 (Not Important), 1 (Slightly Important), 2 (Moderately Important), 3 (Important) and 4 (Very Important). Prior to ranking different barriers based on the responses, Cronbach's alpha test was performed to check reliability and inter consistency of this set of survey questions. The test showed

α= 0.83, which indicates that the set of questions reaches acceptable relatability [6]. The frequency of the survey responses to each question is represented in Fig 12.

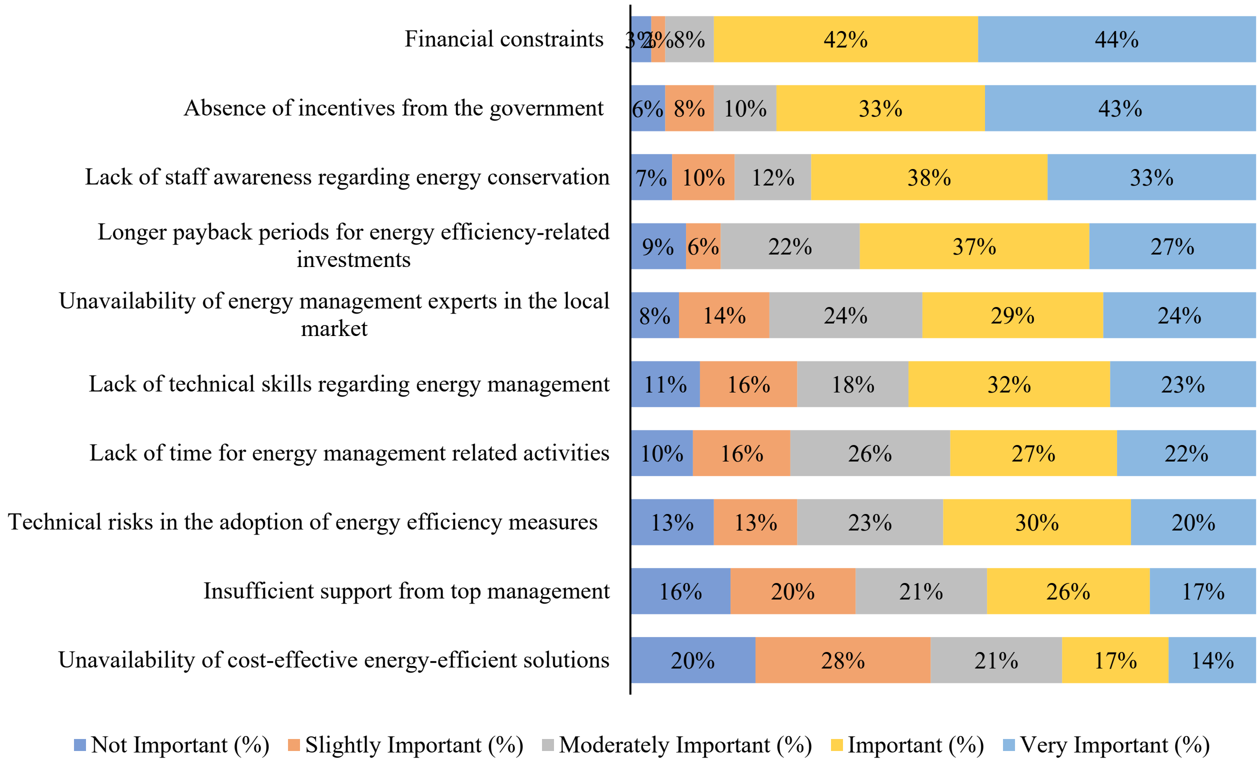

Figure 4.5 Perceived Barriers - Total Sample - Frequency of Responses

Based on the frequency of responses to different options score was calculated, and the barriers were ranked according to this score. The score of each barrier and overall rating is represented in fig 13.

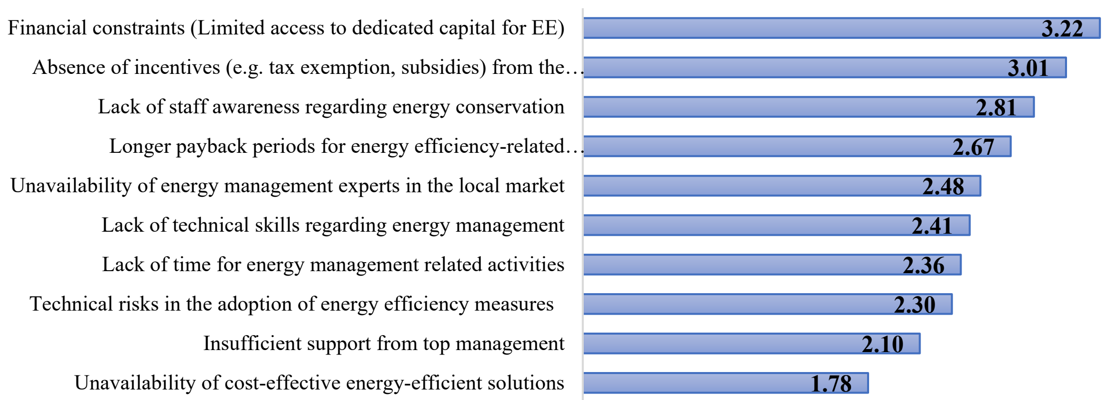

Figure 4.6 Ranking of perceived barriers

As already discussed in methodology chapter, these empirical barriers can be effectively explained through a theoretical framework, hence Table 4 highlights the rank and related theoretical background of each barrier.

Table 4.1 Rank and Classification of Studied Barriers

Rank	Empirical Barrier	Classification
1	Financial constraints (Limited access to dedicated capital for energy efficiency related projects)	Economic
2	Absence of incentives (e.g., tax exemption, subsidies) from the government	Regulatory
3	Lack of staff awareness regarding energy conservation	Awareness
4	Longer payback periods for energy efficiency related projects	Risk
5	Unavailability of energy management experts in the local market	Technology/ Services provisions
6	Lack of technical skills regarding energy management	Information
7	Lack of time for energy management related activities	Organizational
8	Technical risks in the adoption of energy efficiency measures	Risk
9	Insufficient support from top management	Organizational
10	Unavailability of cost-effective energy efficiency solutions	Technology/Services Provision

It has been found that "Financial constraints" is the most important barrier to energy efficiency. Limited access to dedicated capital for energy efficiency projects has been identified as the main obstacle and 86% of the respondents consider it very important or important. Previous studies in different regions of the world also present related results. A survey conducted in the textile sector of Bangladesh points out that inadequate capital is the biggest hurdle in industrial energy efficiency [7]. Rohdin et al. conducted a study in 30 Swedish foundries and found that limited access to capital is key reason for no up taking efficiency related projects [8]. Similarly, a survey of 128 manufacturing companies in Italy ranked lack of devoted capital for energy efficiency investment as the most important barrier [9].

“Absence of incentives (e.g., tax exemption, subsidies) from the government” was ranked second in the list of important barriers to energy efficiency. This can be classified as institutional or regulatory barrier. Many governments give incentives in the form of tax reduction/exemption or subsidies to increase energy efficiency in the industrial sector. For instance, the UK’s “Enhanced Capital Allowance Scheme” provides a 100 percent first year tax relief to the organization spending on approved energy efficient technologies [10]. The Netherland government offsets up to 55% of the annual cost of investment for energy-saving equipment in the calendar year in which the equipment was obtained under the context of Energy Investment Deduction (Energie Investeringsaftrek, EIA program) [11]. Although efforts have been made by Pakistan government to promote industrial energy efficiency through legislations such as National Energy Efficiency and Conservation Act (NEECA) 2016, there is a need to re-evaluate and effectively implement these regulations.

The respondents rank “Lack of staff awareness regarding energy conservation” on the third place. The awareness of energy efficiency and conservation play a vital role in the energy efficiency [12]. This is a significant issue in developing countries where personnel have less knowledge about climate change, its effects and relation with energy consumption and energy management. Often machines are left to operate in idle mode or signs of energy loss such as leakages etc have been ignored. Training programs for staff at every level of the industry is necessary for creating awareness about these issues. The “Longer payback periods for energy efficiency related projects” was considered the fourth most important barrier to energy efficiency. A previous research has shown that 80% of companies based their investment decisions for energy efficiency related projects on payback periods [13]. The generally accepted payback period for such investments is maximum 3 years or lesser, however it may have some variations depending upon the sector and technology [14]. Sorrel et al. [15] concluded that risk aversion can be a potential reason behind constraining energy efficient measures with short payback periods. This may be attributed as a rational response to technical and financial risk associated with such investments and business and market uncertainty.

“Unavailability of energy management experts in the local market” was ranked at number fifth in the list of ten barriers to energy efficiency. In developing countries, availability of experts for energy system optimization and management is a major problem [15]. A similar study conducted in Bangladesh also pointed the inadequacy of technical experts in the field as an obstacle to energy efficiency [7]. This can be attributed to the lack of proper training infrastructure for preparing such experts. Unavailability of trained human resource is a well-known problem and government is also aware of this fact. In November 2020, the National Energy Efficiency and Conservation Authority (NEECA) has launched a "Training of Trainers (TOT)" program in collaboration with the Climate Technology Center Network (CTCN) under UNFCCC across Pakistan. The goal of this program is to create a pool of trainers to train future workforce for energy management and audits. Similarly, some other organizations like UNIDO and APO are also arranging training and capacity building programs to fulfil the market needs for energy experts.

"Lack of technical skills regarding energy management" and "Lack of time for energy management related activities" was ranked at sixth and seventh position, respectively. Both theoretically belong to the category of organizational barriers. The ability of recognizing energy efficiency opportunities and manage organization's energy consumption is critical. Several studies pointed out that lacking the expertise to identify and implement energy efficiency opportunities is a result of inadequate or imperfect information [9], [16]. Lack of time for energy management activities is also an important organizational barrier. Industries often have other priorities to invest their time in and this is a reason behind neglecting the energy efficiency opportunities. Trianni and Cagno [9] found that time spent finding new energy efficiency opportunities, analyzing data, and gathering information is primarily a hidden cost that must be considered. Moreover, efforts to devote time to energy efficiency do not always lead to certain results: production efforts therefore tend to be of more weight since they can lead to some results.

The barrier "Technical risks in the adoption of energy efficiency measures" was ranked at eighth position. The survey results show that 50% of the respondents marked it as very important or important. Technical risks such as production disruptions or breakdowns may outweigh the benefits of energy efficiency. However, such risks are more significant if the technology is new and unfamiliar. Since many of the technologies used in engineering-economic models and recommended in energy efficiency journals, on the other hand, are well known, accurate, and commonly used. Energy efficient lighting, condensing boilers, thermal insulation, energy efficient motors, thermostatic radiator valves, and lighting controls are some examples of these. The technical risk associated with these technologies appears to be low in most applications. As a result, unless perceptions differ significantly from reality, technical risk appears unlikely to provide a reason for rejection in most cases.

"Insufficient support from top management" and "Unavailability of cost-effective energy efficiency solutions" were given the lowest ranks of ninth and tenth, respectively. Only 17 percent of the respondents consider lack of management support, a very important barrier to energy efficiency. This represents that support from top management is available in energy management activities. The unavailability of cost-effective solutions was also not considered as a significant barrier to energy efficiency.48 % of the respondents thinks it as not important or slightly important obstacle. This shows that cost-effective energy efficiency solutions are available in the market.

4.8 Drivers of Industrial Energy Efficiency Improvement

The respondents were asked to rate the importance of 8 drivers to energy efficiency: using a Likert scale 0 (Not Important), 1 (Slightly Important), 2 (Moderately Important), 3 (Important) and 4 (Very Important). Before ranking the drivers based on the responses, Cronbach's alpha test has been performed to check reliability and inter consistency of the survey items. The test showed α= 0.7, which indicates that the set of questions reaches acceptable relatability [6]. Fig 14 represents the frequency of responses for the perceived drivers .

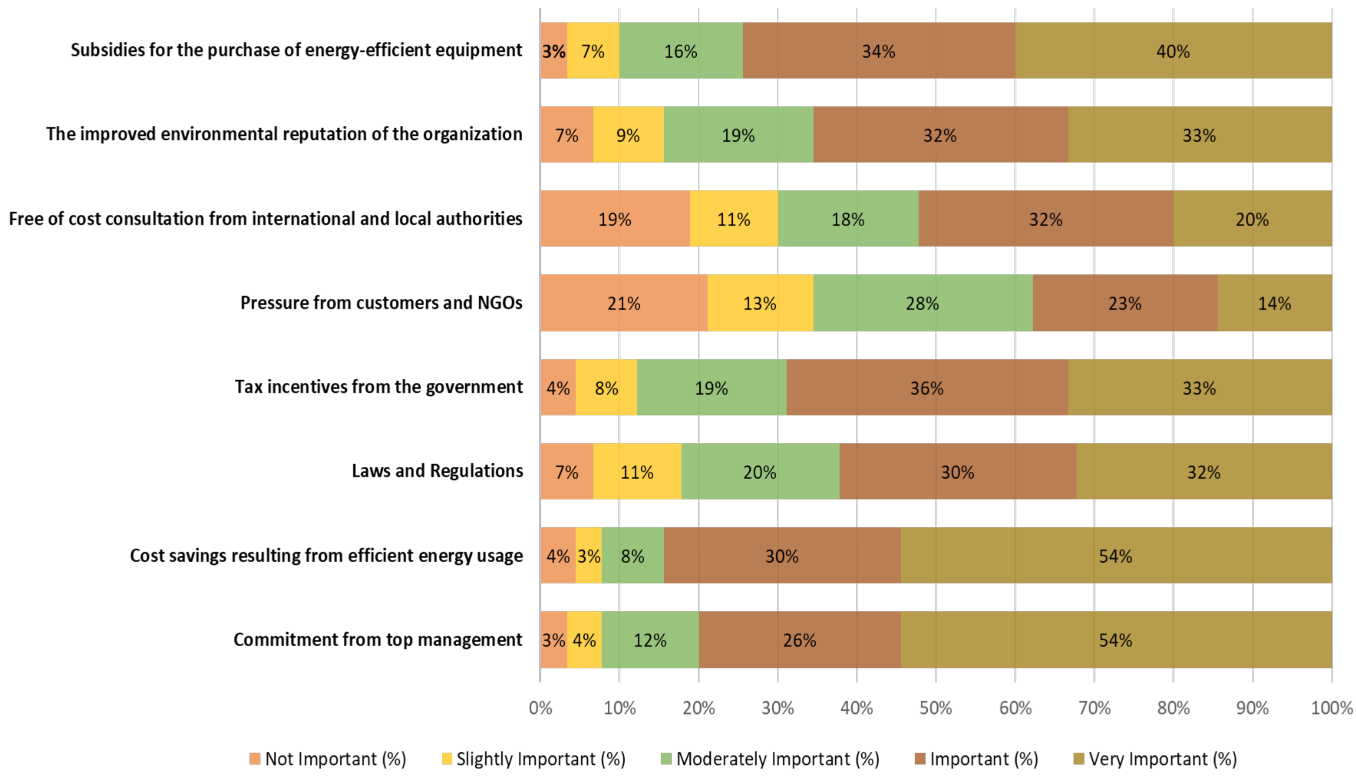

Figure 4.7 Perceived Drivers -Total Sample-Frequency of Responses

The drivers are ranked according to the average score given to each by the respondents. Fig 15 shows the overall ranking of the drivers.

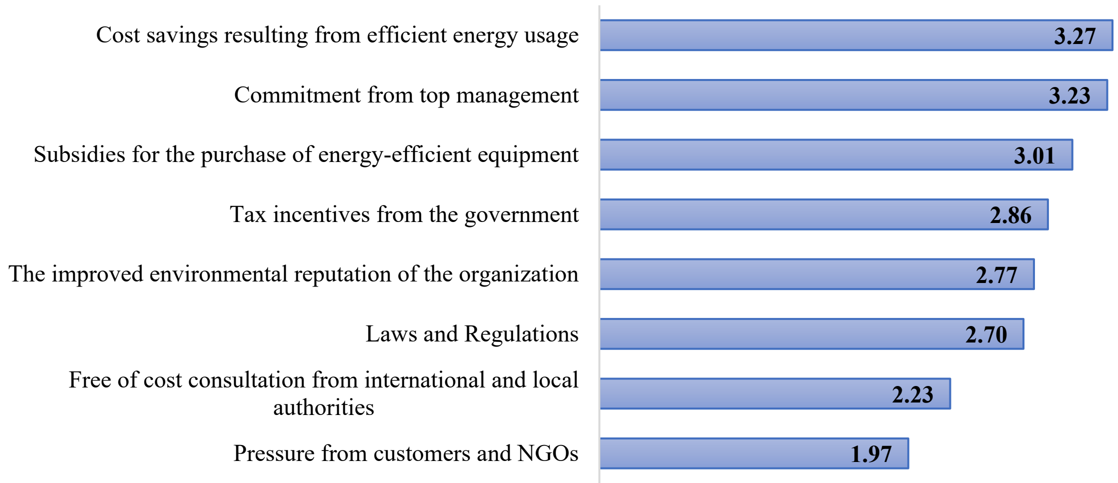

Figure 4.8 Ranking of Driving Factors for Energy Efficiency Improvement

The highest ranked driver is the "Cost saving resulting from efficient energy use" with a score of 3.27 and 40% of respondents marking it as very important and 34% as important. Thollander et al. [17] classified it as financial driving force for improving energy efficiency (See Table 1). The respondents pointed that savings from energy efficiency interventions can provide a competitive edge to their organization and consider it the key reason for investing their time and money energy efficient practices and technologies at their companies.

The "Commitment from top management" was ranked second with an average score of 3.23 and 65% rating it as very important or important. Theoretically, it is classified as organizational and behavioral factor for energy efficiency improvement. Then again, the finance related drivers "Subsidies for the purchase of energy efficient equipment" and "Tax incentives from government" were ranked third and fourth, respectively.

Another organizational driver "The improved environmental reputation of the organization" was considered as the fifth most important driving force for investing in the energy efficiency by the respondents. "Laws and regulations related to environment and energy efficiency (e.g. National Energy Efficiency and Conservation Act 2016, Environmental Protection Laws)" were ranked 6^{th} among the eight drivers for energy efficiency.

The "Free of cost consultation from international and local authorities (e.g., UNIDO, NEECA, PEECA)" is classified as informational driving force for improvement in energy efficiency in the literature[17]. The survey participants gave it a low average score of 2.23 and consider it the second least important driver. The lowest rank was given to the external driving factor "Pressure from customers and NGOs" and only 37% of the respondents consider it as an important driver for energy efficiency improvement.

Table 4.2 Rank and Classification of Studied Drivers

Rank	Empirical Driver	Classification
1	Cost saving resulting from efficient energy use	Financial
2	Commitment from top management	Organizational

3	Subsidies for the purchase of energy efficient equipment	Financial
4	Tax incentives from government	Financial
5	The improved environmental reputation of the organization	Organizational
6	Laws and regulations related to environment and energy efficiency	Regulatory
7	Free of cost consultation from international and local authorities (e.g., UNIDO, NEECA, PEECA)	Informational Driving forces
8	Pressure from customers and NGOs	Regulatory

Summary

This chapter presents the results of the survey conducted in 90 industries comprising of 13 sectors. The state of energy management practices in the industrial sector of Pakistan is investigated. A brief section of this chapter discusses the awareness level of respondents regarding the global energy management standard known as ISO 50001. Following this, the barriers to energy efficiency are studied and the barriers are ranked with respect to the importance given to each by the respondents. In last section, the drivers of energy efficiency improvement for the industries are discussed and results are presented ranking the importance of each driver in the improvement of energy efficiency.

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Chapter 5: Conclusion and Recommendations

This work is an attempt to investigate three aspects of energy savings in the Large-Scale Manufacturing (LSM) sector of Pakistan; (i) current energy management performance, (ii) barriers to energy efficiency improvement, (iii) drivers of energy efficiency improvement. Only 20% of the surveyed industries meet the necessary criteria for complete adoption of an energy management system based on the minimum requirements set adopted for this study. Absence of energy managers, lack of documented procedures for energy management and nonexistence of staff training programs were found as key issues. This result indicates the presence of an energy efficiency gap in the LSM industries. It has been found that the most notable barriers hindering the energy efficiency improvement are lack of access to dedicated capital for energy efficiency related projects, absence of incentives (e.g., tax exemption, subsidies) from the government and lack of staff awareness regarding energy conservation. In case of drivers, cost savings resulting from efficient energy use was found to be the most important driving force for adopting energy management practices and improving energy efficiency in the industries. Commitment from top management , subsidies for the purchase of energy efficient equipment, tax incentives for industries and improved environmental reputation of the organization were also considered effective drivers by the industries.

The results of this study demonstrate the presence of a significant unexploited resource saving potential that can only be utilized thorough effective management of energy consumption. Proper implementation of energy management practices will boost industry's competitiveness and curb the growing energy demand. Based on the results of this study, the most notable barriers, and drivers for the improvement in energy efficiency are related to finance. So, it is recommended to the policy makers in Pakistan to provide incentives in the form of subsidies and tax exemptions to the industry for energy management related activities. Energy efficiency awareness programs will also help in improving the current scenario of industrial energy consumption. Moreover, given the global trends in energy management, a proven strategy is to introduce and promote ISO 50001-Energy Management standard in the LSM industry.

Annexure A

Questionnaire Used in this study.

Survey on the implementation of energy management practices, drivers and barriers in the Industrial Sector of Pakistan

The filling of this survey form will only take 5 to 7 minutes of your time. In case you need any clarifications or have any queries, please feel free to contact at :

Email: munibahmad313@gmail.com
Phone: 0312-3717111

Thank you so much for your cooperation.

* Required

1. Email *

2. Name (Optional)

3. Phone Number (Optional)

4. Name of your company *

5. Your Position *

Mark only one oval.

- Top-Level Management/ Administrative level
- Middle-Level Management/ Executory
- Low-level Management/ Supervisory

6. Department *

Mark only one oval.

- Administration
- Maintenance
- Production
- Health & Safety
- Quality Control
- Procurement
- Other: ____________________

Industry Information

Please fill in the information related to your industry.

7. The region where your industry is situated *

Mark only one oval.

- Punjab
- Sindh
- KPK
- Baluchistan
- Islamabad region
- Gilgit Baltistan

8. Industrial sector: *

Mark only one oval.

- Textile & Apparel
- Food,Beverages & Tobacco
- Automotive
- Steel & Foundry
- Cement
- Fertilizers
- Chemical & Chemical Products
- Electrical & Electronic Equipment
- Mechanical Machinery
- Ceramics
- Paper & Paper Board
- Petroleum
- Rubber & Rubber Products
- Other: ______________________

9. Number of Employees: *

Mark only one oval.

- 1-25
- 26-50
- 51-100
- More than 100 employees

10. The average age of the installed equipment: *

Mark only one oval.

- 1-5 years
- 6-10 years
- 11-15 years
- 16-20 years
- More than 20 years

11. Any implemented management systems at your industry (Please check all those apply): *

Check all that apply.

- [ ] Quality management system (ISO 9001)
- [ ] Environment management system (ISO 14001)
- [ ] Health and safety management system (OHSAS 18001)
- [ ] Food safety management system (ISO 22000)
- [ ] Energy Management System (ISO 50001)

Other: [ ] ______________________

Energy Management and Conservation Practices at the industry

This section collects information about the current practices adopted by your industry to improve energy performance.

12. There is a formal energy policy of the industry? *

Mark only one oval.

- Yes
- No

13. There is a documented process of energy planning in order to improve energy performance? *

Mark only one oval.

- Yes
- No

14. Does top management regularly review the energy performance of the organization? *

Mark only one oval.

- Yes
- No

15. Submetering is done to record energy consumption at the process level/machinery? *

Mark only one oval.

- Yes
- No

16. Energy Performance Indicators (KPI's) to gauge energy performance are defined? *

Mark only one oval.

- Yes
- No

17. Trainings related to energy efficiency and management are conducted for the staff? *

Mark only one oval.

- Yes
- No

18. The procurement of products, services, and equipment are evaluated based on energy efficiency? *

Mark only one oval.

- Yes
- No

19. Energy efficiency is considered in the design of the site/new projects? *

Mark only one oval.

- Yes
- No

20. Energy Manager has been appointed to monitor energy performance? *

Mark only one oval.

- Yes
- No

21. Energy audits have been performed in the past? *

Mark only one oval.

- Internally
- Externally
- Both
- None

22. Are you aware of the ISO 50001 Energy Management System? *

Mark only one oval.

- Yes
- No
- To some extent

Drivers of Energy Management and Conservation Practices

Please rate the factors which can drive energy management and conservation practices in your industry.

1 = Not important
2 = Slightly important
3 = Moderately important
4 = Important
5 = Very important

23. Commitment from top management *

Mark only one oval.

	1	2	3	4	5	
Not important						Very important

24. Cost savings resulting from efficient energy usage *

Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

25. Laws and Regulations (e.g. National Energy Efficiency and Conservation Act 2016, Environmental protection laws) *

Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

26. Tax incentives from the government *

Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

27. Pressure from customers and NGOs *

Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

28. Free of cost consultation from international and local authorities (e.g. UNIDO, JICA, GIZ, NEECA, PEECA) *

Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

29. The improved environmental reputation of the organization *

Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

30. Subsidies for the purchase of energy-efficient equipment *

Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

Barriers to Energy Management and Conservation Practices

Please rate the barriers to the adoption of energy management and conservation practices in your industry.

1 = Not important
2 = Slightly important
3 = Moderately important
4 = Important
5 = Very important

31. Financial constraints (limited access to dedicated capital for energy efficiency related projects) *

Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

32. Technical risks in the adoption of energy efficiency measures (e.g. Production failures) *

Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

33. Unavailability of cost-effective energy-efficient solutions *

Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

34. Insufficient support from top management *

Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

35. Lack of time for energy management related activities *

Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

36. Lack of staff awareness regarding energy conservation *

Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

37. Lack of technical skills regarding energy management *

Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

38. Absence of incentives (e.g. Tax exemption, subsidies) from the government *

Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

39. Longer payback periods for energy efficiency-related investments *

Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

40. Unavailability of energy management experts in the local market *

Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

Thank you for taking the time to complete this survey

The fact that you are reading this message indicates that you have completed the Questionnaire and I am extremely grateful for contributing your valuable time. Please let me know if you have any suggestions or comments. Your feedback will be highly appreciated.

41. Comments/Suggestions (Optional)

____

____

____

____

____

42. Can I contact you if any further information is required? *

Mark only one oval.

◯ Yes

◯ No

Annexure B

3rd International Conference on Sustainable Energy Technologies (ICSET 2021)
Peshawar, Pakistan, 10 August 2021

Energy Management Practices in the Large-Scale Manufacturing (LSM) Industries of Pakistan; A Case Study

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ABSTRACT

The industrial sector of Pakistan is the largest consumer of energy resources in the country. The sector is witnessing a growing demand for energy which is expected to accelerate further in the future. However, the country's high dependency on imported fuels, rise in energy prices, and environmental issues pose a serious threat to industrial growth. In this scenario, effective management of energy consumption is vital for sustainable development. This work aims to evaluate the current energy management practices in the industrial sector of Pakistan. The research focuses on the Large-Scale Manufacturing (LSM) industries, the most important industrial sector of the country. A comprehensive survey-based study is conducted in 90 LSM industries from 13 major manufacturing subsectors. The questionnaire addressed critical aspects of energy management, including energy planning, implementation and monitoring of energy management practices, and continual improvement in the industry's energy performance. The outcomes of the survey are analyzed based on a minimum requirements list. It is highlighted that only 20% of the industries practice energy management. The unavailability of energy managers, the inadequacy of established energy management practices, and the absence of staff training programs were identified as significant problems. The findings of this study will be helpful to both business and government policymakers.

KEYWORDS: Energy Management, Industrial Energy Efficiency, Large-Scale Manufacturing (LSM) Industries, ISO 50001