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Empirical Investigation of Energy Management Practices in Cement Industries of Bangladesh

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Abstract:

The aim of this study was to demonstrate and analyze the energy management practices in the cement industries of Bangladesh. The outcome of this study shows that there are some barriers in energy management and energy efficiency practices; Lack of staff consciousness, insufficient attention from government and bureaucratic intricacy are most significant among them. On the contrary, the most dominant drivers of energy management are risk of high energy prices in the future, highly motivated employee and high demand from consumer and Non-Government Organizations. According to the study, around 4-5% of energy efficiency can be enhanced with the assistance of energy management practices in cement industries. However, many industries are unaware of the idea of energy service companies as there is a lack of information about such company, and deficit of competent human resources in the energy management sector.

Keywords: cement industry, energy management; industrial efficiency; energy-intensive industry; energy policy.

1. Introduction

Bangladesh, a densely populated country with a population of 180 million in 147570 square kilometers, has shown improved industrialization index and growing GDP in recent years. The economy of Bangladesh is one of the five fastest-growing in the world despite endemic corruption and lack of private sector investment. On the supply side, the growth is driven by manufacturing and construction, and on the demand side, private consumption has remained sturdy, underpinned by strong remittance and rural income growth [1]. Now to cope up with the rapid growth of industrialization, it is imperative to have increased electricity generation. It has increased the installed capacity by a factor 3.3 over the last eight years and actual served energy is doubled in that period. The idea of energy efficiency and improved energy management system at the demand side can not only reduce the gross use of energy but also helps to achieve reduced emission of carbon [2]. There is a growing interest in this field of research throughout the world in industries like pulp and paper, steel, textile, cement, ceramic etc. as seen from the examples [3-5]. However, research in the field of energy management and efficient energy use in the industrial level is insufficient in Bangladesh.

The cement industry in Bangladesh has shown double-digit growth over the last five years. According to a survey conducted by the Cement Manufacturers Association (CMA), the production capacity is 40

million tons per year, and actual production is sticking around 32 million tons in 2018 [7]. The country has significant construction projects such as the Padma Bridge, Metro Rail, Karnafuli Underwater Tunnel, Dhaka-Chittagong Elevated Expressway and Dhaka Elevated Expressway that will shape up an intriguing market of cement in coming years [6, 7]. Under the Plan Delta, Bangladesh is implementing 100 economic zones around the country; seventy-nine of them are under construction currently. There are currently 32 local and foreign cement industries in Bangladesh to serve the huge demand. Around 80% of the total market demand is catered by local industries, and foreign companies delivered the rest [8]. According to a study carried out by Sustainable and Renewable Energy Development Authority (SREDA), working under Power Division of the Ministry of Power, Energy and Mineral Resources (MPEMR) of Bangladesh, cement industry consumes 2.90% of total primary energy consumed[9] . So energy management and efficient use of energy is an unavoidable and significant task in this growing industrial field of Bangladesh.

This study sheds light on the energy management potentials and current situation in the large cement industries of Bangladesh. The aim of this study was to explore the following factors in cement industry of Bangladesh:

1. Energy efficiency potential in major cement industries of Bangladesh.
2. Energy management activities performed by these industries
3. Drivers to energy efficiency in cement industry
4. Barriers to energy efficiency in cement industry
5. Long term plan for efficient energy management

Different countries in the world addressed the problem of lack of energy efficiency measures and conducted several types of research in the energy management field [10, 11]. For example, previous studies from China [12], United States of America [13], Ethiopia [14], Thailand [15] and Turkey [4] explored the potential of energy efficiency in cement industry from the different perspective. Hasan et al. investigated two prior research [16, 17] on the prospect of energy efficiency in the steel and textile industry of Bangladesh. However, to the best of our knowledge, this is the first work that demonstrates the energy management practices of the cement industry of Bangladesh. Therefore, this paper can unveil the window of energy management research in Bangladesh, keeping in mind the recent industrial and economic growth. Furthermore, the other developing countries working on industrial energy management sector can extract the lessons from this research.

2. Use of energy in Bangladesh

Bangladesh, a South Asian country having an area of 147,570 km². The population density of this country is very high, amounting an overall population of 163 million people [18]. Despite a deficiency of adequate energy supply, the gross domestic product (GDP) of Bangladesh is following an ascending direction for recent years [19, 20]. This is estimated to rise to 3367 million USD in 2050 [21]. There is a strong linkage between growth in GDP and the growth in energy use [22-24]. The vision of Bangladesh government is to assure the supply of electricity to its overall citizens by 2021. Figure 1 depicts electrical power generation by various fuel types in Bangladesh. It is clearly seen that a large portion of electricity generation comes from natural gas (53.48%), and renewable energy sources have the least amount of electricity production.

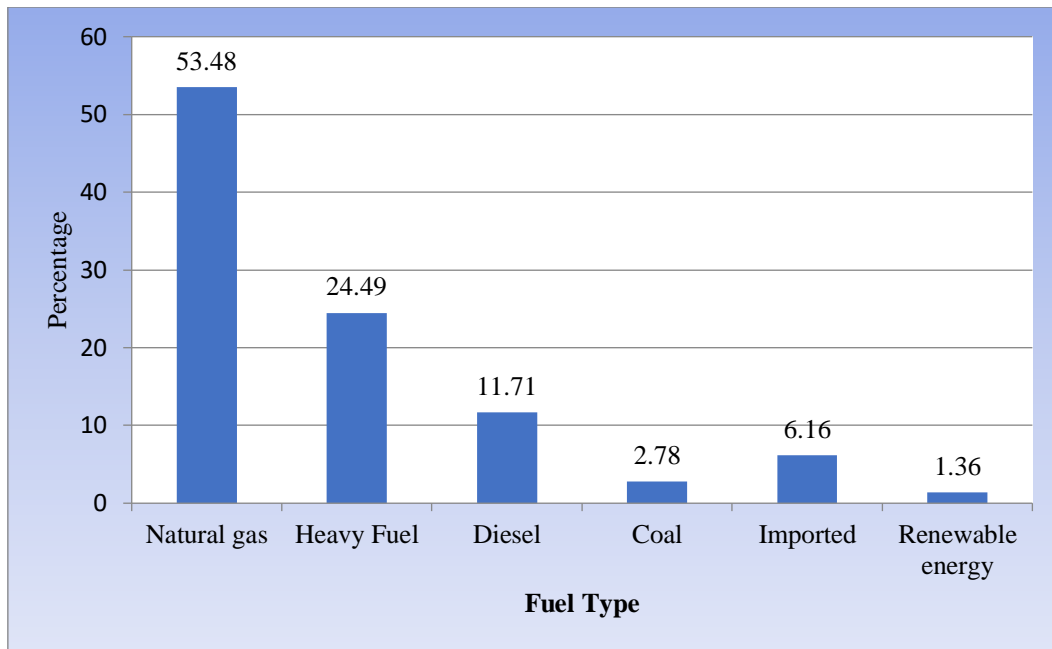


Figure 1. Electrical energy production by fuel category (percentage) in Bangladesh [25]

Figure 2 depicts the electricity generation by plant category in Bangladesh. It is observed from figure 2 that the reciprocating engine category has the largest share (36%) in Bangladesh and other categories of plants have more or less contribution [25].

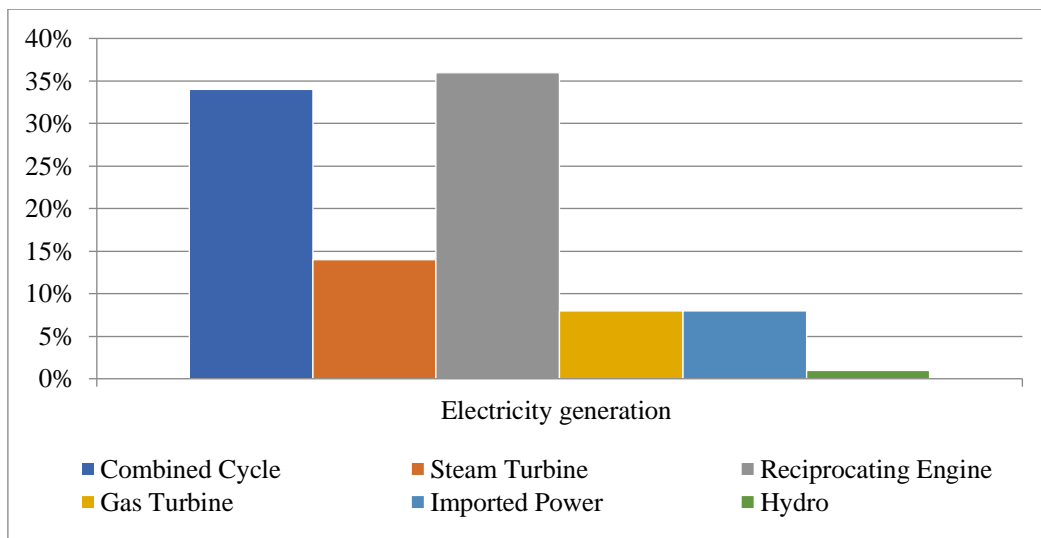


Figure 2. Electricity generation by plant category (percentage) [25]

It is reported that the total energy consumption in 2018 was around 62 TWh with per capita energy consumption of 374.62 kWh [25]. Table 1 lists five years (from 2014-2018) electricity consumption of Bangladesh that indicates the country's growing demand, and in the upcoming year of 2041, it is forecasted to be around 427 TWh [25, 26]. Residential sector consumed 53.31% of total electricity (highest amount), and the industrial sector was in the second position with 29.55% consumption in 2018 [25]. As per the forecast, in 2041, the industrial sector is likely to be the highest consumer of energy and transportation sector will be second-highest [18].

Table 1. Year-wise electricity consumption in Bangladesh [25]

Year	Electricity Consumption (TWh)
2014	40
2015	45
2016	50
2017	55
2018	62

3. Cement Industry in Bangladesh

Bangladesh stood 40th in the list of largest cement market of the world. Despite many obstacles such as the skyrocketing price of raw materials, rapid increase of interest rate, depleting domestic currency, and price rise of necessary goods, Bangladesh cement industry has shown around 9% growth in 2018. Per capita cement consumption is depicted in Figure 3 from 2011 to 2018. At 2018, the cement consumption is 184 kg per capita which is nearly double of per capita consumption of 2011. Urbanization, infrastructure development, growing real estate sector are the main driving force of the cement market in recent years [8].

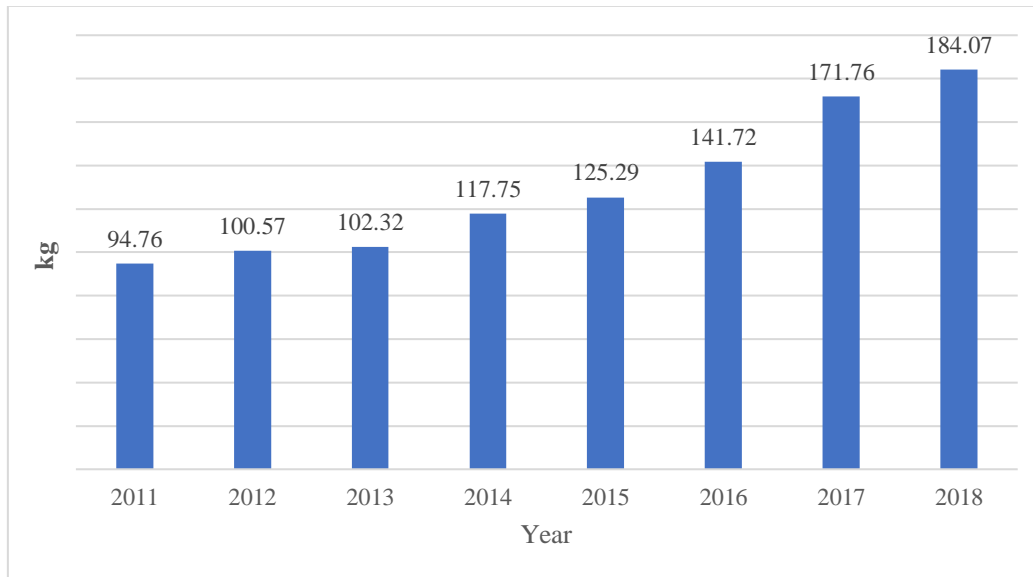


Figure 3. Per capita cement consumption in kg from 2011 to 2018 [8]

According to EBLSL research, the total sales volume of cement was around 15 million metric tons, whereas, in 2018, the sale volume increased to 32 million metric tons [7]. Year-wise capacity and sales volume of cement are shown in Figure 4. Cement industry in Bangladesh is concentrated; approximately 81% market share is occupied by ten cement manufacturers [8]. The major players in this industry are also planning expansion sensing high future demand. Seven Rings cement will have a post-expansion capacity of 8.50 million Mt/year, Premier cement will have 8.00 million Mt/year [27] and Crown cement will have 5.80 million Mt/year [28]. The present installed capacity of significant cement industries is shown in Figure 5. Present installed capacity is around 52 million Mt, and by 2022 installed capacity will be 80 million Mt/year [29].

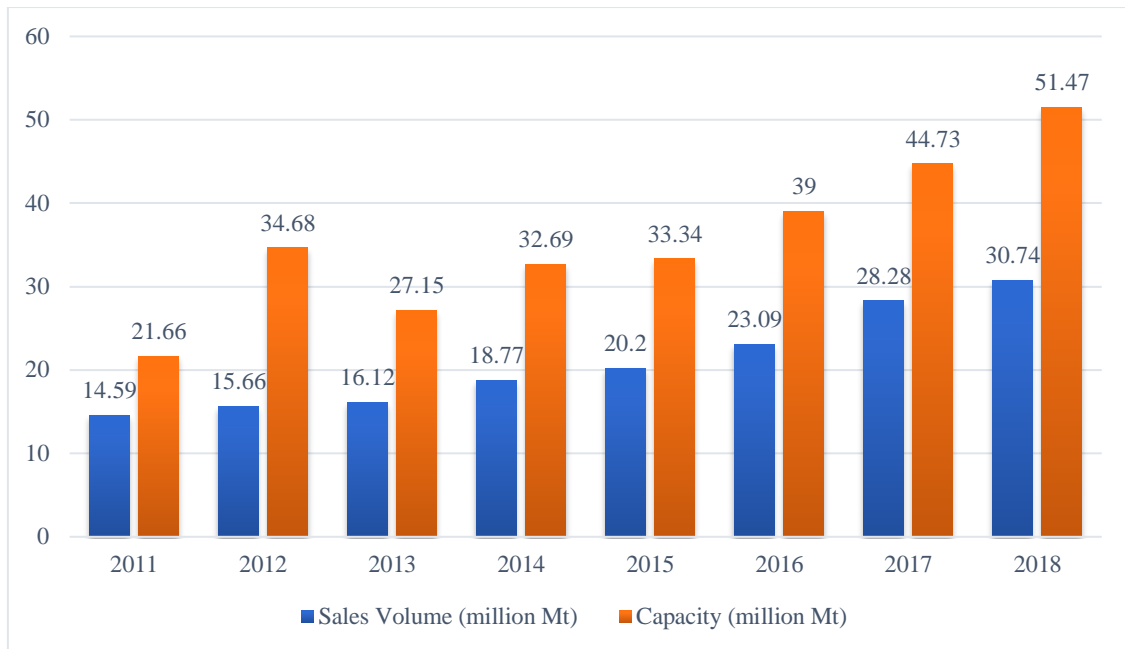


Figure 4. Capacity and sale volume of cement in a million Mt for 2011-2018 [8]

The cement mills of Bangladesh are mainly of two types; Ball Mill (BM) and Vertical Roller Mill (VRM). BM type cement industry is around 85% globally, and VRM is around 15% [29]. Top market players, including Bashundhara Cement, Shah Cement and MI Cement have started using cutting-edge VRM technology. This technology provides higher fineness, increased Particle Size Distribution (PSD) and lower power consumption in cement production. So it is expected to lower the cement price for the manufacturers [30]. On the other hand, the government has recently increased gas price from BDT 7.76 to BDT 10.7 per cubic metre for industries and from BDT 3.16 to BDT 4.45 for power generation; this may lead to price rise in cement according to Bangladesh Cement Manufacturers Association (BCMA) [31].

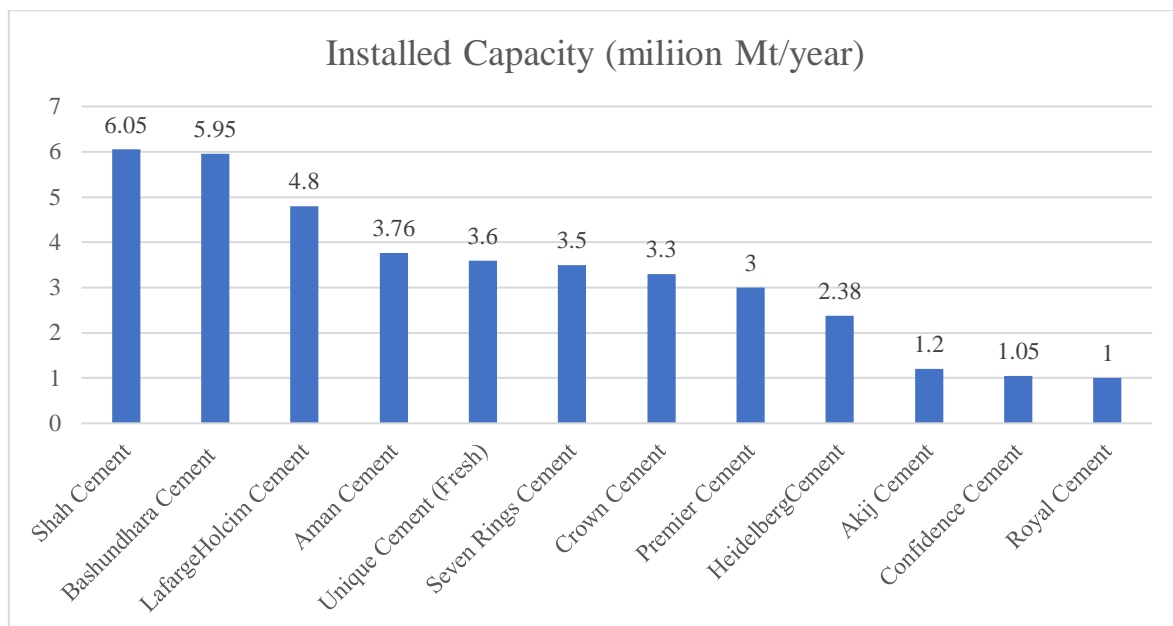


Figure 5. Installed capacity of some major cement company of Bangladesh [8]

4. Energy-Efficient Technologies in Cement Industries

Energy efficiency focuses on the management of lower energy requirement for fulfilment of the same task [32]. Energy efficiency measures in an industry typically concentrate on process optimization. It also deals with the convenient replacement of machinery that is usually used [29]. The process of Cement production can be divided into three main stages. Raw material preparation is the first stage, followed by clinker production and cement grinding [33].

The preparation of raw material typically relies on the usage of electricity [34]. There exist several energy-efficient technologies which can be incorporated with raw material preparation. Among them, the salient options include roller press as pre-grinding to ball mill, vertical mill, enhanced competent classifiers and separators, efficient homogenization of materials and flexible speed drive for raw mill fans [34]. Other prominent options include use of roller mills, efficient transport systems for raw materials preparation [14]; high-efficiency roller mill, high-efficiency fan for raw mill vent fan with inverter [15]; wash mills with closed-circuit classifier [35], bucket elevator for raw meal transport [36]. Conventional ball mills for raw materials grinding can be replaced by efficient mills like roller press as pre-grinding or vertical mill to reduce the electricity use. The use of high-efficiency classifiers and separators provides prevention from over-grinding. Thus it lessens the consumption of electricity. Homogenization of raw materials boosts the ability of flaming in the kiln resulting in reduced power consumption [34].

Clinker production relies on the use of energy more than any other stages. Kiln consumes the biggest amount of energy [34]. Suitable energy efficiency technologies can reduce energy consumption to a great extent. There exist several energy-efficient technologies which can be incorporated with clinker production. Some prominent options are mentioned in Table 2 with a relevant description. Excluding them there exist other salient options like efficient kiln drives, low-pressure drop cyclones for suspension preheater, bucket elevators for kiln feed [36]; modification of inlet duct of grate cooling fan, installation of SPRS (slip power recovery system) for precalciner's fan speed control, optimization of the diameter of preheater's exit gas downcomer duct [15]; seal replacement (SR) [35].

Table 2. Energy efficiency options for clinker production [34, 37]

Energy efficiency measures	Description
Process control and optimization in clinker making	Process control and optimization in clinker making can enhance the quality of the clinker. It can significantly curtail heat consumption.
Combustion system improvement	Air and fuel are mixed together for combustion. Combustion system development can ensure the optimization of this mixing. Thus energy consumption is reduced.
Enhancing the quantity of preheater cycles in Kilns	An additional preheater stage can reduce the temperature of the hot gas through heat recovery. There is an inverse relationship between the number of preheater stages and the temperature contraction ability for the gas. Thus, added preheater stages can lessen fuel consumption.

Low temperature and High temperature heat recovery	Waste heat can be collected from preheaters, clinker cooling system and kilns. This can be used for power generation and thereby lessen electricity consumption. Fuel and raw materials can be dried by using waste heat.
Organic Rankine Cycle (ORC)	Considerable temperature difference exists between the shell of the kiln and the surrounding temperature. Significant heat losses can occur from this. Organic Rankine Cycle (ORC) can be practiced to retrieve the heat losses. This heat can be used for power generation.
Efficient clinker coolers	Three types of cooler systems can be applied for the cooling of the clinker. They are planetary, traveling and reciprocating grate coolers. The capacity of reciprocating grate coolers is very high. They also have the best heat recovery capability.
Fluidized bed advanced cement kiln system	This system helps to reduce the use of energy in comparison with rotary kilns.
Flexible speed drive (To be used in kiln fans)	Fixed speed fans in the kiln can be reinstated by the utilization of flexible speed drives. Thus the electricity consumption can be decreased. Introduction of flexible speed drives will also optimize the operating and maintenance costs.
Flexible speed drive (To be used in clinker cooler fans)	Fixed speed fans in the clinker cooler can be reinstated by the utilization of flexible speed drives. Thus the electricity consumption can be decreased. Introduction of flexible speed drives will also optimize the operating and maintenance costs.
Fuel switch	Apart from fossil fuels, an alternative fuel option can be introduced in clinker production. This option can be waste-derived fuels. This is a feasible alternative, and the use of such type of fuels is expanding in universal cement industries.
Upgraded refractories (To be used in clinker making)	The steel kiln shell secures itself from mechanical, chemical and heats stress by refractories. Improved refractories can save energy by a visible margin. They also have prolonged lifetimes.
Incidental firing (To be used in clinker making)	Indirect firing is suitable for the latest power plants. Direct firing system can be replaced by an indirect firing system. This will help to reduce energy consumption to a great extent.

Cement grinding is another energy-intensive stage of cement production. There are distinct energy efficiency measures which can be applied to cement grinding process. For cement grinding, we see the extensive use of ball mills. Pre-grinding can be incorporated with ball milling to reduce electricity consumption. Adjustable speed drives can replace the fixed speed fans in finish grinding. Thus the electricity consumption can be reduced. It will also help to mediate operating and maintenance costs. Advanced crushing technologies (e.g. the use of ultrasound) can be considered for finish grinding [34]. Other prominent options for energy efficiency include process control and energy management in grinding, upgraded grinding topology for ball mills, enhanced competent classifiers (for finish grinding), enhanced competent cement mill vent fan [36]; vertical roller mill for cement grinding, high Pressure (Hydraulic) roller press for cement grinding [14]. There are also some general measures associated with the energy efficiency in cement production and presented in Figure 6.

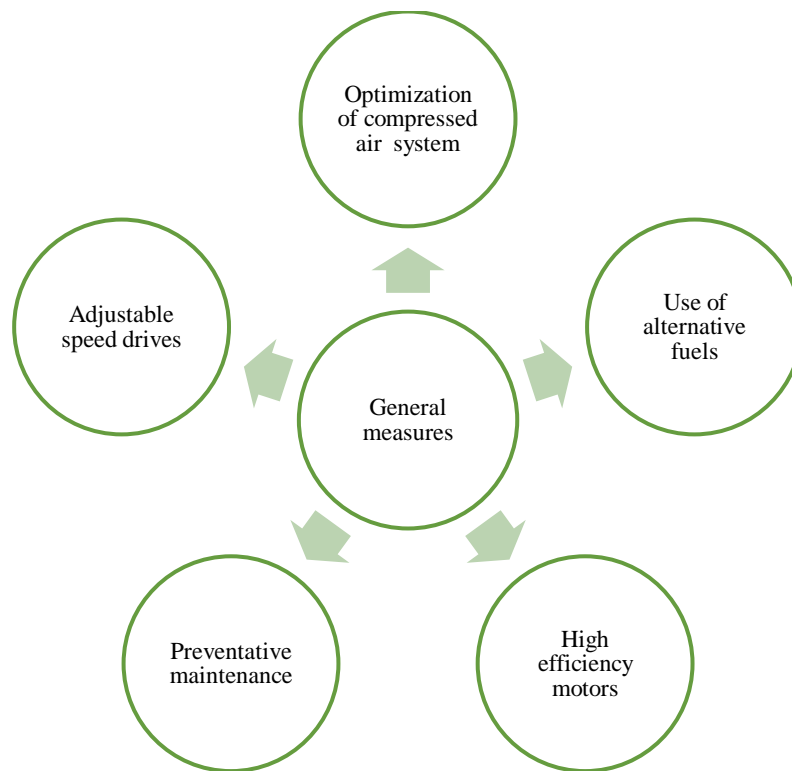


Figure 6. Energy efficiency measures in general [15, 35, 36]

5. Energy management in industry

Energy management plays a vital role in improving the energy efficiency of an organization. It is classified as a fruitful and profitable measure to boost the energy competence of any industry. Capehart et al. illustrate energy management as an efficient way of using energy to enhance profits and strengthen competitive areas [38]. The German Federal Environment Agency termed energy management as a combination of planned and accomplished actions to assure a minimum of energy requirement for a predetermined performance [38]. Ates et al. integrated energy efficiency with energy management. It was described as an action that lessens the CO₂ emission [38, 39].

The effects of greenhouse gas discharge on the environment are indisputable nowadays. Sustainable energy, together with upgraded energy efficiency is a key to minimize the anthropogenic emission by different industries [40, 41]. Efficient energy management framework provides improved energy efficiency together with optimizing the operational cost [42, 43]. Energy management is strongly connected with the production chain and logistics [44]. There are several aspects which are directly

associated with a fruitful energy management scheme. The aspects are energy cost allocation and monitoring, policy, long term strategy, energy manager, management support and pay-off criteria [3, 40, 45]. Figure 7 represents the factors for a fruitful energy management scheme of an industry.

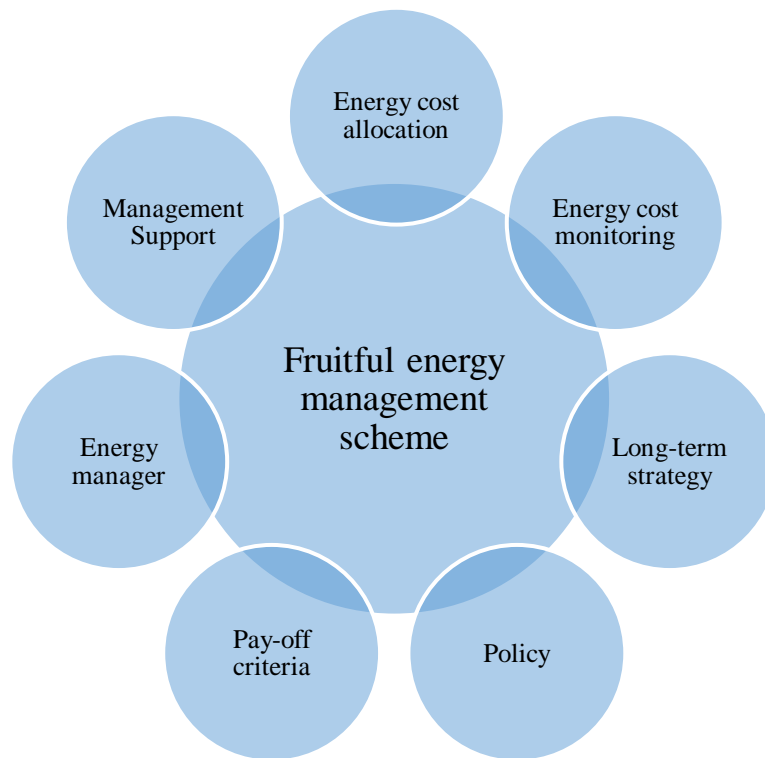


Figure 7. Criteria for a fruitful energy management scheme [45]

Energy cost allocation is a vital factor for efficient energy management of a company. It affects the encouragement of a company to adopt suitable energy efficiency policies [46]. Top managerial support plays a key role in a fruitful in-house energy management system. As is observed, practices of energy management are fruitfully implemented in organizations where there is adequate support from the top management [44]. Successful energy management strategies have been carried out by a lot of countries. Various industries in these countries achieved energy savings by a big margin. In Denmark, several industrial organizations adopted energy management strategies by 2001. This number exceeds 400 industries. These companies consume at least 60% of the total energy in the country [5, 18]. They have made a visible amount of energy savings which varies from 24% to 62% [18].

6. Methodology

Due to lack of prior knowledge about energy management practices in the cement industry of Bangladesh, this research adopted case study approaches [47]. Case studies are based on a detailed investigation of a solitary individual, group or event to look into the causes that incorporate quantitative evidence. Besides, it relies on diverse sources of proof as well as signifies the benefits from the prior theoretical propositions. This sort of study method has its strength to obtain detailed and relevant data derived from multiple factors. The internal legitimacy is, therefore, high that provides a platform for occasional argumentation based on hypothetical development [48].

The data assembled in this investigation was gained utilizing a questionnaire concentrating for the most part on the available measures to promote efficient and effective use of energy among cement enterprises of Bangladesh. The questionnaire is easy to populate, evaluate and report, also it is designed in such a way as to maximize the accuracy and quantity of the obtained information [45]. This questionnaire was previously used in various similar studies; therefore, motivated this research to utilize

the same. This study was conducted in the spring 2019. In this study, companies having energy cost higher than 6% of the turnover were selected [45], and the questionnaire was sent electronically to the person designated as plant manager. The feedback from the respondents was crosschecked over the telephone in the later phase. It has been observed that plant managers are extensively experienced in the production and engineering field for more than 15 years. In this study, the data acquired by perception of the respondents can be considered as valid as well as significant, considering the intensive experience of the respondents. The questionnaire was divided into six sections mainly. The company profile was asked at the beginning of the questionnaire. The following parts were barriers to energy efficiency, drivers for energy efficiency, energy efficiency potential, energy service companies and energy management. The breakdown of the questionnaire is presented in Figure 8.

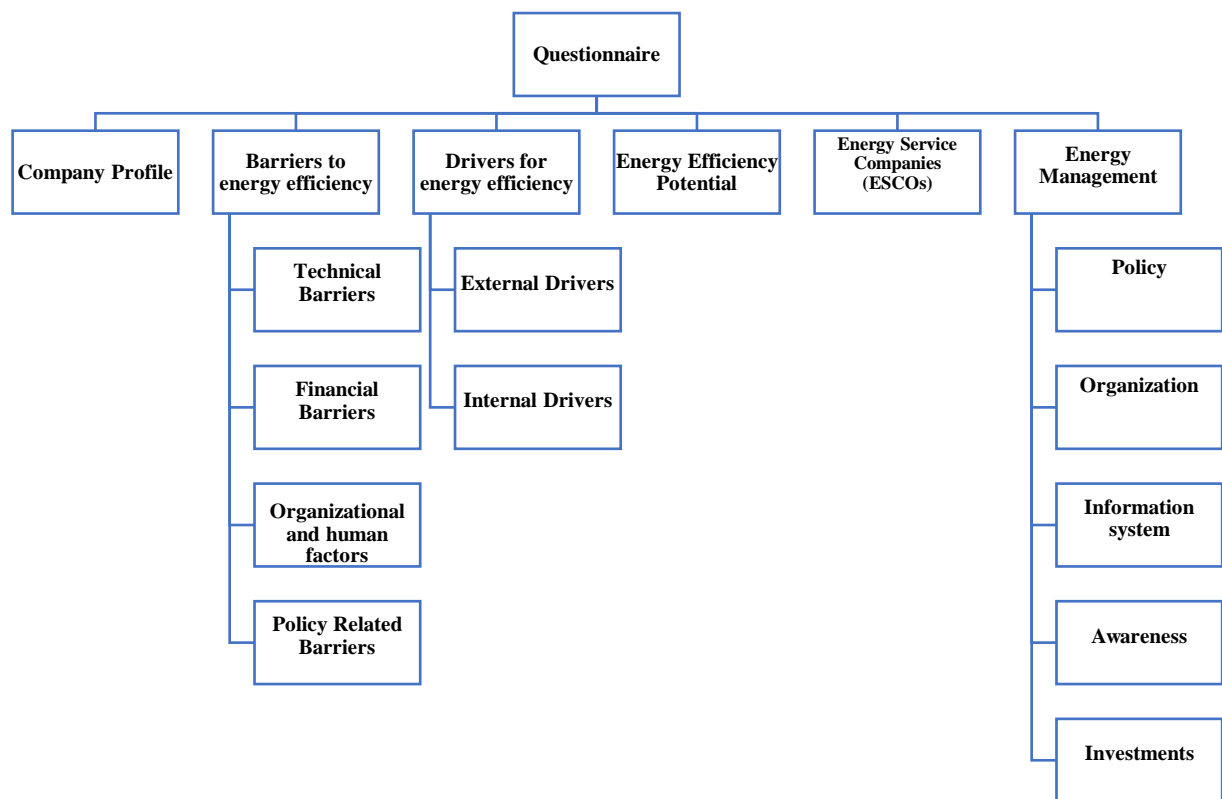


Figure 8. Structure of the questionnaire

This study guaranteed 30% participation which can be considered as a noteworthy figure considering Bangladesh's corporate and research culture [16]. Respondents numerically positioned the apparent barriers and drivers within the range of 1 to 5, where 1 represents "Not important" and 5 represents "Extremely important". Transparent feedback from the respondents was ensured by proper arrangement of data confidentiality measures. Besides, the human inclination was circumvented by averaging and normalizing the reactions. Furthermore, the frequency of responses was done for barriers and drivers to energy efficiency, and barriers to energy service companies in order to identify the number of occurrences of each feedback chosen by the respondents. As a result, this helped to describe the characteristics of the set of responses. Nonetheless, Cronbach's alpha test was carried out to address the reliability issues of the respondent's feedback [49]. A glimpse of the studied companies is given in Table 3:

Table 3. Overview of the studied companies

Topic	Remark
The criterion to select industry	Energy cost > 6% of the total turnover
Questionnaire was sent	23 industries
Total Respondents	7
Response rate	30%
Designation of the respondents	Plant manager
Total questions	64
Payback criteria	Three-four years for most of the companies

7. Results and Discussion

7.1 Barriers to energy efficiency

In Table 4, it is possible to rank the barriers according to their overall average scores. In addition, the frequency of responses is shown in Figure 9. With an average score of 0.93, “Lack of staff consciousness” is found to be the most pressing impediment towards the establishment of energy efficiency in cement industries of Bangladesh as 86% enterprises perceived it as quite important (score of 4 or 5). This barrier is of internal origin [10] and indicates that decision-makers are simply ignoring the possible benefits resulting from the energy efficiency measures. To increase staff awareness companies should provide staff training and awareness campaigns on a regular basis.

Table 4. Perceived Barriers

Barrier Category	Average Score
Lack of staff consciousness	0.93
Insufficient attention from government	0.84
Bureaucratic intricacy	0.78
Complex synodical issues	0.74
Unpredictable nature of energy parameter	0.72
Non visibility of demonstrated technology	0.70
Limited influence on energy management	0.69
Inadequate information about allotment of energy expenditure	0.65
Inadequate financial policy	0.61
Other preferences for capital venture	0.59
Inadequate capital expenditure	0.57
Inadequate financial incentives	0.55
Inadequate technical experts	0.51
Time limitation or other significant work	0.46
Inadequate support from preeminent administration	0.42
Absence of competent managerial measures	0.38
Poor research & development	0.34
Inadequate information about energy efficiency options	0.29
Ambiguity about latent costs	0.25
Complication in inter-divisional collaboration	0.20
Technical uncertainty	0.16
Inadequate technical cost-effective measures	0.09

Furthermore, 78% of respondents felt that enterprises are not getting enough support from the government, hence positioned “Insufficient attention from government” as the second most important

barrier. Having a difference of only 0.06 in average score with the second barrier, bureaucratic intricacy was found to be the third major impediment. This was no surprise because the complex bureaucratic system of Bangladesh is hindering the growth of this country in various other sectors also [50, 51].

The major companies like Shah cement, Bashundhara cement, Meghna cement, Premier Cement have already started using advanced technologies at their factories [52-54]. Therefore, we can note that technical barriers are not perceived as particularly pertinent, as in the lowest positions we find barriers such as “Technical uncertainty”, and “Inadequate technical cost-effective measures” with an average score of 0.16 and 0.09 respectively.

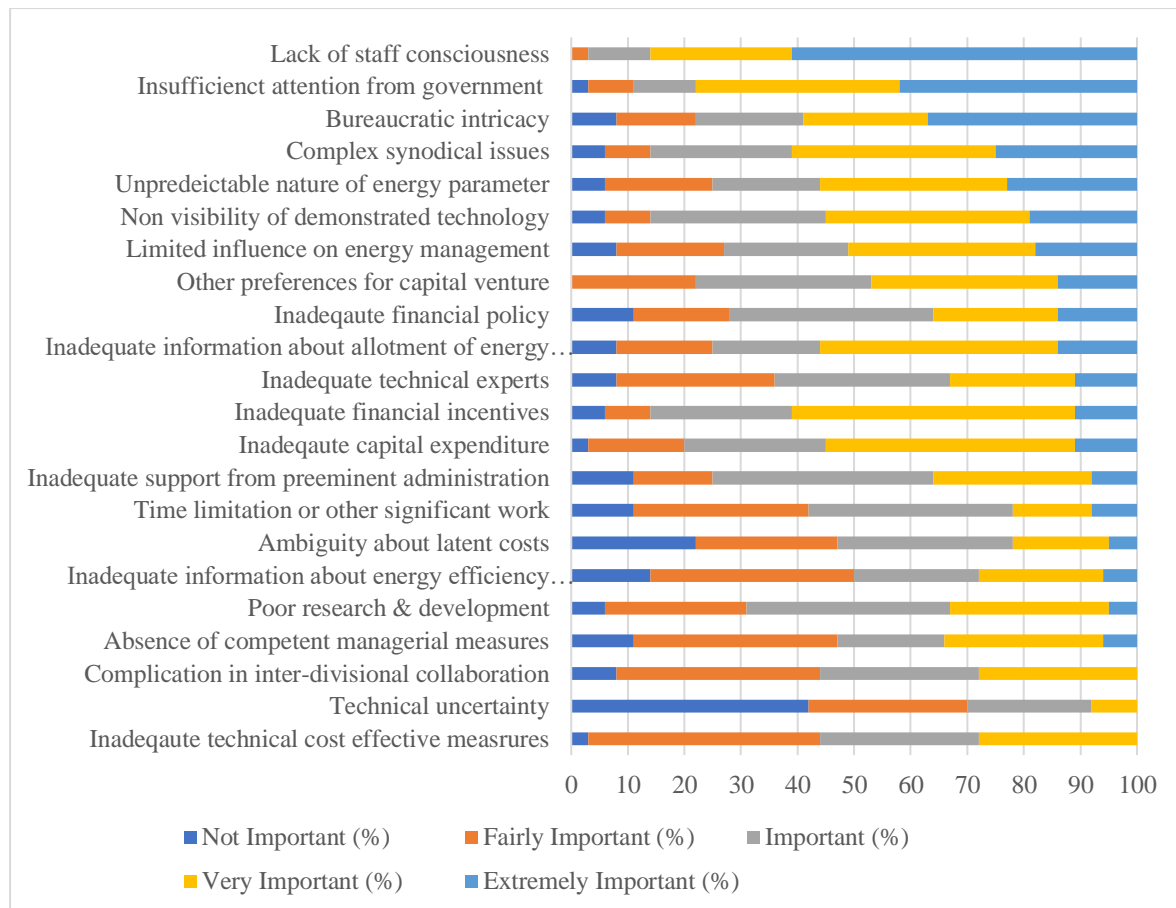


Figure 9. The perceived barriers to energy efficiency- frequency of response

Looking at the frequency of response from Figure 9, an interesting fact is identified about “Lack of staff consciousness”. None of the participants marked this issue as not important, which indicates the importance of staff awareness to adopt any changes in an organization. The same propensity is observed for “Other preferences for capital venture”. Interestingly, this is not identified as a high ranked barrier by the participants. On the contrary, none of the participants marked “Inadequate technical cost-effective measures”, “Technical uncertainty”, and “Complication in inter-divisional collaboration” as extremely important.

Nonetheless, a few comparable research [14, 55] directed in the continent of Africa accentuated “lack of capital” as their major hindrance towards developing a sustainable energy-efficient cement industry followed by “Subsidised power supply”. Then again, a developed economy like Kuwait [56], identified “Inadequate regulation support” as a major barrier alongside “Lack of environmental awareness by the industry”. Thai cement industry identified barriers related to management concern about production disruption, investment cost, and time required for energy efficiency projects [57]. So, it is seen that due

to variation in geographical location, size of economy and nature of energy consumption, the perceived barriers change from one country to another country.

Despite having a noticeable lack of published research in regard to energy management in the context of Bangladesh two past research [16, 17] on textile and steel industry attempted to capture the holistic view of the particular industries and reported contrasted barriers compared to this study. However, interestingly, all these energy-dense ventures are under the same energy policy, culture, infrastructure and regulatory body.

7.2 Drivers to energy efficiency

The ranking of the drivers are presented at Table 5. Moreover, Figure 10 incorporates the frequency of responses. By looking at the drivers both from the Table 5 and Figure 10, it is seen that “Risk of high energy prices in the future” is the most dominant driver as 50% of the plant managers identified it as an extremely important factor (average score of 0.93), followed by “Highly motivated employee” (with 42% of the companies regarding it as extremely important). According to the study of [58], considering a broader perspective, our first driver can be categorized as an economic driver, both second and fifth driver falls under the category of organizational driver, the third one is a market driver, and the fourth one can be labelled as a policy instrument. The fact that economic and organizational factors have the greatest direct effects on energy efficiency improvements [59] is also supported by various other prior research [44, 46].

Table 5. Perceived drivers to energy efficiency

Driver Category	Average Score
Risk of high energy prices in future	0.93
Highly motivated employee	0.86
High demand from consumer and NGO	0.81
Certification in sustainable system	0.77
Organizational involvement in information and support	0.73
Agreements with tax dispensation	0.71
Energy audit endowment	0.69
Favorable loans for energy efficient financing	0.68
Locally available energy consultancy	0.68
Viable reduction in carbon emissions	0.64
Environmental benefits (other than CO ₂ reduction)	0.64
Subsidies for energy efficiency schemes	0.62
Rules and regulations	0.60
Owner's requirement	0.59
External investment	0.57
Acquaintances within the energy sector	0.55
Expanse minimization due to lower energy consumption	0.53
Assistance from energy professionals	0.49
Assurance from preeminent management	0.45
Energy management scheme	0.41
Energy blueprint	0.33
Global competition	0.25

Nonetheless, looking at the frequency of responses from Figure 10, it can be seen that each of the participants considered “Risk of high energy prices in future” and “Highly motivated employee” as important. The same propensity applies for “Organizational involvement in information and support”.

However, each of the participants marked “Energy blueprint” and “Energy management scheme” as important. Interestingly both of them are low ranked drivers.

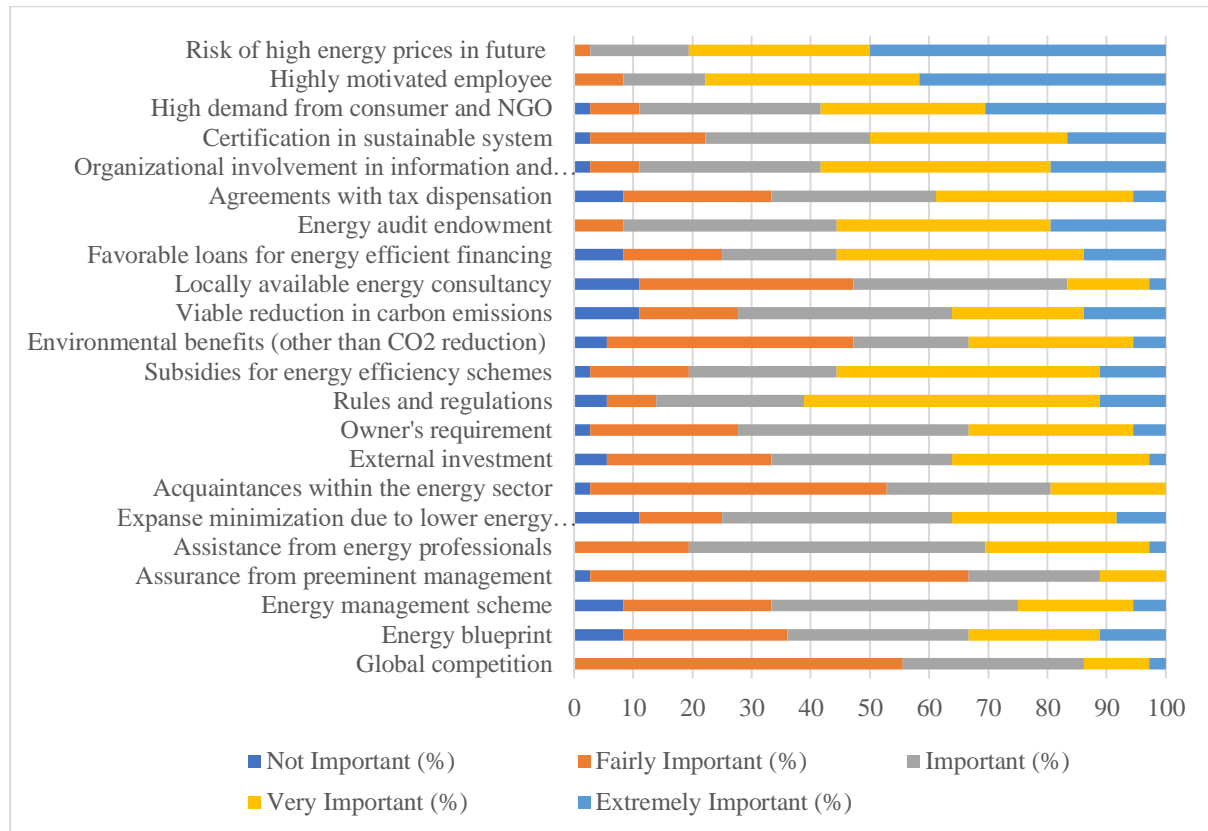


Figure 10. The perceived drivers to energy efficiency- frequency of response

Relating our findings to the other studies, the monetary driver, “Risk of high energy prices in the future” was found to be recurring in the context of both steel and textile industry of Bangladesh as well as the foundry industry (an energy-intensive industry like cement industry) of Europe [60], whereas the other factors differ widely. The second most important driver (average score of 0.86), “Highly motivated employee” can be of great advantage towards ensuring less energy-intensive cement industry as motivated employees will be more likely to accept and implement energy efficiency measures [61]. Besides, this driver will tremendously help to nullify the major barrier “Lack of staff consciousness” owing to the fact that it will be very easy to raise awareness among motivated staffs. Frequency of response shows that 31% of plant officials considered “High demand from consumer and NGO” as extremely relevant because high demand from consumers will keep the business running at all conditions; consequently, it will ensure cash flow to support energy management practices. On the other hand, Bangladesh is in the 40th place of global cement market; hence it is not quite there to contribute to the world’s cement consumption. That’s why we see that only 3% of the respondents considered global competition to be extremely important. But in recent times, some companies are seen exporting cement to various parts of the world which is a good sign for the industry [62].

7.3 Energy efficiency potential

All the participants were first asked about the percentage of energy use that could have been reduced if all the companies could install all accessible, financially savvy technologies on the market. Vertical Roller Mill (VRM), a cutting edge technology, can be installed to grind the hard, nodular clinker from the cement kiln instead of inefficient ball mills that can save up to 15% energy [63]. Inclusion of flexible speed drive used for cooling purpose can further reduce electricity consumption. Furthermore, to reduce fuel consumption, wet-type kilns can be replaced by modern dry-type kilns on a per ton of clinker basis

[7]. As the motors are of MW size new highly efficient motors can save a large amount of energy even if the percentage seems low (1-2%). Since fan blades are continuously in contact with cement dust, they become highly corroded, and a regular clean-up of fan blades can save 3% energy [64]. Automated mill airflow control system can retrieve additional 5-10% energy. On realizing sustainability, clinker substitution, alternative fuel use, and waste heat recovery could potentially lessen 11% energy consumption cost and will open doors for exporting fossil fuels as well as enhancement of 4.5% of in manufacturer profit. As a result, majority of the respondents expressed that at least 9–10% energy can be saved with the existing technologies. Moreover, the internal audit conducted by the enterprises as well as small scale energy-efficient pilot studies undertaken by some factories clearly indicated the scope of increased energy saving through energy management. Therefore, when asked about improved energy efficiency, plant managers stated that additional 5% energy use could be reduced if proper energy management measures can be applied. Finally, all the respondents provided the highest score in the final inquiry, which was about rating the importance of considering a system perspective to evaluate alternatives for improved energy efficiency.

7.4 Energy management

The matrix of energy management, a structured model, is used in this study that correlates different levels of energy management with the main lines of potential activities concerning the administration of energy consumption in an enterprise [65]. This assessment tool involves energy policy, organization, information systems, awareness and investment to diagnose the current state of energy management for a particular organization [66]. So as to facilitate organization's administration to deal with energy matters, energy management aspects were determined by the weighted aggregate of members' reactions to the distinctive purposes of survey questions where weights were taken from the current scientific literature for similar industry [40, 45].

As seen in Figure 11, the energy matrix suggested that among various different components, the organizational element is lagging behind the most compared to other elements and a similar result was found in [64] which also pointed out the absence of any formal delegation of responsibility for energy consumption. That being the case, the industries should come forward and include full-time energy managers in their management structure as currently, companies have either no energy experts or part-time energy experts with only limited authority. Lack of investment in increasing energy efficiency premises positioned the investment element in the second place, indicating the top management to be a reliable sponsor as well as a supporter of companywide energy-related issues [38]. Likewise, top management should invest more, undertake both short and long term energy policy, raise awareness within the organization and build a robust information system to monitor consumption, track expenditure and identify system faults.

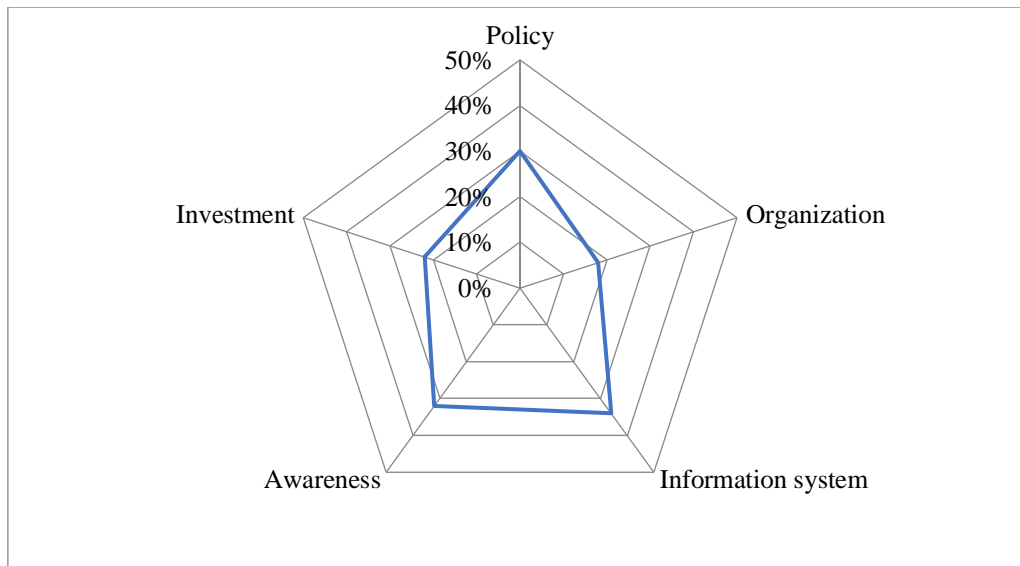


Figure 11. The matrix for assessing the energy management in the cement industries of Bangladesh

The success of energy-efficient cement industry will take off if both long- and short-term energy policy can be acquainted and implemented owing to the fact that policy-driven actions and innovation will be critical to unlocking the unexplored potential for energy efficiency [67]. As the nation is experiencing a critical stage of its development and hoping to arrive at upper-middle-income status by 2021, it introduced nine key energy efficiency strategies over the span of the last 20 years. Among these various schemes, the “Energy Efficiency and Conservation Master Plan up to 2030” by Sustainable and Renewable Energy Development Authority (SREDA) of Bangladesh has the most key points [9]. Acknowledging the value of effective environmental management this policy undertook energy auditing as its core mechanism and developed Energy Auditor Regulations (EAR). This EAR framework is considered as an excellent building block to ensure energy efficiency, which will start its operation from selective industries at its preliminary stage. These regulations are more likely to empower investment at scale from both government and private sector, which in turn could create opportunities to employ more labours in the cement industry. Alongside expanding manufacturer's incomes due to energy-saving measures, the willingness to develop cement capacity will potentially lead to increased employment rates in this sector. Streamlined implementation and enforcement can further boost progress and accelerate market transformation.

Based on the result of our study, our recommendation for the policymakers of Bangladesh and all the stakeholders related to cement industry would be to raise awareness about energy efficiency and its benefits towards sustainable development including climate change. Besides, entrepreneurs are suggested to implement energy efficiency from a pure energy security perspective as a nationwide energy crisis is on the rise. Optimistically this will support the future amelioration of industrial energy efficiency as well as the energy management research field.

7.5 Energy service companies

In spite of the fact that the concept of ESCOs emanated from the US in the early 1970s [68], our results uncovered that the potential of ESCOs in Bangladesh is completely unexplored not only in the cement industry but also in other equivalent heavy industries [16, 17]. However, various relevant researches [24, 69, 70], conducted on different countries identified this as an imperative element in the energy management pipeline as ESCOs are capable of reducing energy costs, saving energy and decreasing operations and maintenance costs at their customer's facilities by analyzing, developing and funding energy-intensive projects. Table 6 represents the average scores, and Figure 12 shows the frequency of responses. “Insufficient information regarding ESCOs” is the prime perceived obstacle with 97%

respondents acknowledging its severity (from important to extremely important). Obtaining an average score of 0.9 this scenario is the outcome of several key factors like limited information about the benefits of energy efficiency investments and technologies, lack of familiarity with energy-efficient products, lack of awareness of benefits, and an apparent risk when evaluating potential investments [45, 71].

Table 6. The barriers to ESCO

Barrier category	Average Score
Insufficient information regarding ESCO	0.90
Shortage of trained professional in energy management	0.79
Absence of regulated measures for energy parameter	0.66
Inadequate stakeholders	0.60
Excessive service fee	0.49
Lack of credibility	0.37

As it is a manufacturing sector, the requirement for unskilled labour is much greater than that for skilled labour. About 80% of the employees are minimally educated and at best 2% of them have management education [64]. As a consequence, our finding of “Shortage of trained professionals in energy management” is prevalent with 83% of the participants considering it as the second most important barrier (average score of 0.79). Besides, “Absence of regulated measures for energy parameters” and “Inadequate stakeholders” are also responsible for the poor proliferation of ESCOs across the country.

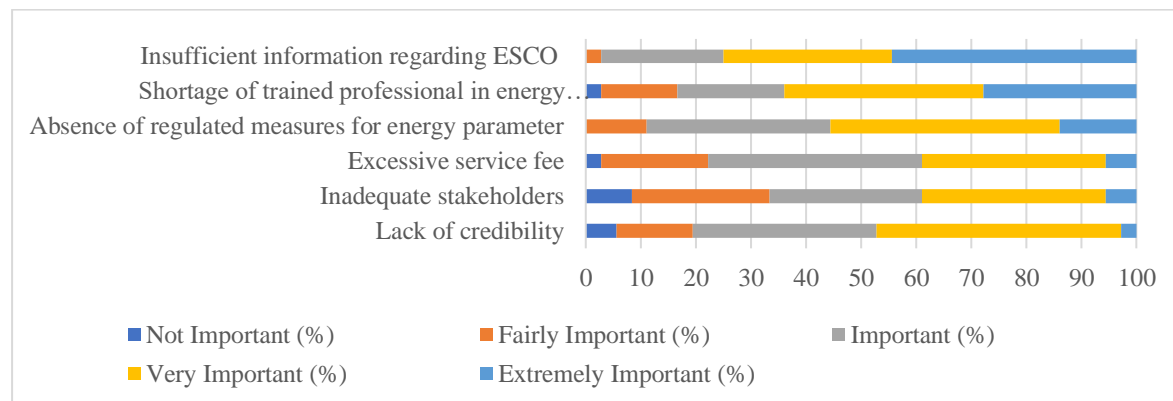


Figure 12. The perceived barriers for consulting with energy service companies- frequency of response

In order to popularize ESCOs in a developing country like Bangladesh, performance-based contracts can be introduced between enterprises and energy service providers as opposed to fixed-fee energy efficiency contracts since it gives no assurance of improved energy efficiency [72, 73]. For skilled energy service providers, the cost of knowledge assimilation per KWh of improved energy efficiency is much less due to repetitive use of their knowledge which sets them in an advantageous position before their potential clients. Awareness of local banks on ESCO should be increased to improve the financial mechanism needed to implement energy efficiency. Implementation of pilot projects through government support can boost the ESCO market. ESCOs can be more appealing by attempting a wide variety of additional services apart from their traditional obligations so that developing countries like Bangladesh feel more secured about them as predatory ESCOs can add fuel to existing challenges [68].

8. Conclusion

The purpose of this research article was to investigate energy management and energy efficiency at the cement industries of Bangladesh. The primary study is novel as no study is conducted so far in this

theme, focusing on Bangladesh. The authors believe that this paper will help the researchers, industrialists and governmental organizations to study the loopholes in energy management and energy efficiency at the cement industries in Bangladesh.

The results explore major identified barriers and drivers to energy efficiency from the respondents. The study points out that the obstacles can be overcome with proper steps taken by both industry and government. Full energy-saving potential can be achieved with the help of proper energy management practices as well as the implementation of energy-efficient technology. A structured model is applied to understand the energy management matrix in this study. The model points out that proper policy, both long term and the short term should be integrated into the industries. Dedicated energy manager and proper investment can trigger the energy management practices in this sector. The authors hope that the outcome of this study will be beneficial to improve energy management practice and energy efficiency at the cement industries of Bangladesh, which involves governmental organizations, policymakers and management of cement industries.

Despite having a small sample size, these preliminary findings indicate that the energy management of cement industry is worth digging considering its growth, financial revenue and energy consumption in Bangladesh. This research is a bit of a bigger riddle with regards to improve energy efficiency in the industrial sector of Bangladesh. Therefore, this research creates scope for further in-depth statistical analysis that might reveal the most effective measures in establishing energy efficiency.

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