INDUSTRIAL ENERGY EFFICIENCY - BARRIERS AND FUTURE PROSPECTS

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Abstract
Research has recognized an extensive potential for energy efficiency improvement within the industrial sector, which is accountable for a significant share of global energy consumption and subsequent greenhouse gas emission. This study discussed the major barrier found in the literature in different industrial environment and it has been observed that the classification of the barricades to energy efficiency are diverse for different firms or establishments. Some barricades are very substantial in majority of the industrial establishments (financial/capital related, informational) while position of further barricades differs considerably across sectors. No single policy could be able to cater the diversified industrial segments. As an alternative, a variety of approaches is likely to be required, which will be helpful for the addressing the barriers of individual circumstances.

Keywords – Barrier, Energy Efficiency, Investment, Industry

Introduction:
The worldwide oil calamity in 1970s and subsequent environmental issues put forward the energy conservation programme as a main concern globally. Hereafter, human impact on the environment needs an instant attention and energy conservation practices put forward a time and cost-effective answer to lower air pollution and CO_2 (International Energy Agency, 2016). Residential energy consumption contributes to the approximately 30 % of the global energy consumption and the same will be increased with the urbanization growth, population and change in life style. According to global studies, dwellers in developing countries are now living in a comfortable lifestyle, by utilizing new electrical domestic device such as room heaters, refrigerators and air-conditioners, which is also a key driver in increase in energy consumption in residential sector (Norzalina et al., 2014). Energy sector is major contributor for the greenhouse gas emission and contribute almost three-quarter of the emission and with major share of industrial usage (Ritchie, 2020).
The energy consumption pattern of industrial sectionconsists of different type of industries which includes manufacturing, assembling, agriculture, mining, and construction (Abdelaziz et al., 2011).Industrial energy efficiency has the potential to increase the commercial competitiveness and subsequently helps in the reduction in the energy consumption and respective carbon emission. Therefore, improved energy efficiency subsequently improved energy supply security, which ensure a sustainable development for the betterment of the society. Improvement in the energy efficiency by end users are considered as a pertinent measure to decrease the energy related emission of carbon dioxide and an economical way to improve the energy security (IEA, 2011).

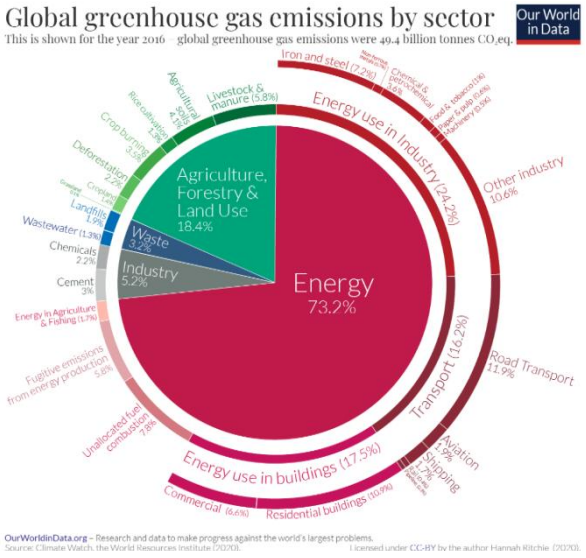

Fig.1 – Global greenhouse gas emission by sector

Majority of the industrial establishments faces financial gravities due to the continual increment in the cost of energy. In European countries, major emphasis is given on the energy efficient improvement projects and which are considered as the finest method to complete the significant targets set by the European Commission wrt Green House Gases emission and decrease in energy consumption. Despite of the financial reimbursement by lesser payback period of the investment and subsequent reduction in operating costs through reduction in specific energy consumptions many organizations operate in an ineffective way.

Organization's choice to defer or discard the implementation of various energy efficient measures, despite these measures are commercially beneficial and simple in execution, is considered a paradox. The main model utilizes to describe the difference among the optimal and existing level of energy efficiency is the barrier model. (Sorrell 2004, Trianni and Cagno, 2012).

Around the globe only 33 % of the final energy use comes under Today only around one-third of final energy use is covered by obligatory energy efficiency policies which includes various codes and standards by different governments. The growth of these codes and standards to include the all-energy use is also weak.

Objective

The major objective of the paper is to study various barriers of energy efficiency in industrial environment. It also examines atmosphere in which they arise, their importance, and the requisite explanations to overcome these barriers. To tracedifferent studies, following scholarly databases was searched: ScienceDirect, Web of Science, and Scopus utilizing the mentioned search threads: 'Energy efficiency', barriers of energy efficiency, energy conservation, efficiency improvement in industry.This topic published in Energy Policy, Energy Economics, Journal of Cleaner Production, Energies and Energy Policy.

Key Definition

A **barrier** for energy efficiency is defined by Sorrell et al.(2004). is "a postulated mechanism that inhibits investment in technologies that are both energy efficient and economically efficient.

Energy Intensity is defined as the energy consumed per unit in the context of industrial energy practices and which is inversely proportional to energy efficiency; lesser the energy requirement for any unit production process, the higher is the energy efficiency (Soni et al., 2017).

Energy efficiency is defined by the United States Energy Information Administration (EIA) "to use technology that requires less energy to perform the same function".

Energy efficiency gapdenotes to the difference between the energy efficiency levels observed and those considered as optimal according to engineering fundamentals or it is the mismatch between the theoretically achievable level of efficiency and the implemented one is basically known as energy efficiency gap (Jaffe andStavins1994).

Energy-efficiency improvements are not only limited to "retrofitting", i.e., refining the efficiency of existing equipment or machinery and processes but also includes the importance of any type of energy efficiency initiatives in new manufacturing setup and equipment or machine and implementation of latest technology.

Small and medium enterprises are defined by different countries based on the capital investment on plant and machinery, annual turnover and number of employees.

Barriers

In literature barriers has been classified by different various types: social and institutional barriers, Technical, Financial, Managerial, Information provision, Internal and External barriers etc. Barrier can also be varied according to energy efficiency measures, such as comfort in implementation, modification in process requirement as per customer demand, precise technical requirements, production interruption, etc (Cagno and Trianni, 2014).Sorrell et al.(2000) has categorised barriers into economic (market failure and non-market failure), Behavioural and Organizational barriers which has been corroborated by the many other authors (Thollander and Ottosson, 2007; Rohdin and Thollander, 2006;Palm, 2009).Main barrier summary found in the literature is mentioned in the Table -1.

Table-1

Main barrier summary to industrial energy efficiency

Sr. No	Industrial Sector		Country	Reference	Main Barrier
	Single	Multiple			
1		Residential, industrial and commercial sectors	India	Reddy and Shrestha, 1998	Lack of awareness, high capital investment and uncertainty of savings
2		Multiple	Australia	Harris et al., 2000	Small rates of return and longer payback periods
3		Multiple	UK	Sorrell S et al., 2000	Shortage of time, different priorities for capital investments, and inappropriate technology
4	Foundry		India	Nagesha and Balachandra , 2006	Economic, awareness and information barrier, Financial and behavioural barrier

5	Foundry		Sweden	Rohdin et al., 2007	Capital issue, technical risks, lack of budget funding
6		Textiles, Metals, Food, Chemicals, Paper,	Greece	Sardianou 2008	Bureaucratic procedures for financial support, restricted capital access
7		Industrial sectors	Switzerland	Cooremans 2012	Low concentration in energy-efficiency involvements, other priorities for capital investments
8		SMEs	China	Kostka et al., 2013	High preliminary capital expenditure, absence of economic incentives
9		Iron and Steel, Plastics and Chemicals, Food	Ghana	WentemiApeaning and Thollander 2013	Issue of funding, access to capital, diversion of capital for other priorities
10	Metal manufacturing		Italy	Cagnoand Trianni, 2014	Implementation issues, barriers vary significantly with intervention considered
11		SMEs	Pakistan	Hassan and Asif 2017	Capital, problem of production disruption, poor equipment performance, lack of public policy, scarcity of requisite technical staff
12		SMEs	Italy	Trianni et al., 2015	economics issues, informational and behavioural barriers
13	Aero-space		UK	Lunt et al., 2014	Accountability issue, risk, issue of capital, Bounded rationality, Fear of product quality, Fear of impacting health & safety
14		Commercial and Service sector	Germany	Schleich 2009	Requisite information, hidden costs, risk and uncertainty
15	Foundry		Europe	Trianni et al.,2017	Hidden costs, Access to investment, Adverse selection, bounded rationality, accountability of energy costs
16	Process industry		UK	Walsh and Thornley 2012	Stakeholder engagement and strategic mapping and the need for capital support for infrastructure
17	Steel Industry		Indonesia	Soepardi et al 2018	Financing, Institutional, Information, Economic, Market structure, Technical, Expertise, Regulation
18	Manufacturing		Singapore	Chai and Yeo, 2012	Technical risk, perceived high cost, Lack of Information, lack of govt incentive
19		Small Scale Industry - SSE with Forging, Railway, auto and tractor parts	India	Anil et al., 2017	Policy and Regulatory Barrier, Personal & Informational Barrier,
20	SMEs		Zimbabwe	Muzamwese T.C (2016)	policy framework issue, old equipment, insufficient funding mechanisms, limited information, economic incentives issues, technical capability problem

Many different studies have show edexperimental evidence for the presence of barricades for the energy efficiency. The nature of these barriers is heterogeneous. Different types of barriers are experienced differently among different technology adopters and vary between technologies. Subsequently, several diverse methods to interpret and classification of barriers appeared in the literature (Fleiter et al., 2011).

Blumstein et al. (1980) defined and classified several types of social and institutional barriers pertaining to economical energy conservation activities. The type of identified barriers are: (i) Misplaced Incentives, (ii)Financing, (iii) Regulation, (iv) Market Structure, (v) Lack of Information, (vi) Custom.

Fig. 1 – Word Cloud of Major Barriers

Another classification of barriers was given by the Intergovernmental Panel for Climate Change as follows: (a) Innovation in technology, (b) Financing, (c)Prices, (d) Market Structure and Functioning, (e)Trade and Environment, (f) Information Provision, (g)Institutional Frameworks and (h) Behavioural Norms.

The study of Almeida et al. delivers an information on energy-efficient motor technologies, whichclassify the barricadesas - (a) Awareness (b) different technical choices, (c) Financial, (d) Internal struggles, and (e) structure of market

Muzamwese (2016) has found the various issues for mainstream energy efficiency improvement projects in SMEs in Zimbabwe and major barricadesincluded werein relation to financeand technical issues, policy awareness and different problems in the firms. In addition to the challenges numerous actions were also discussed to surpass the major barriers.Trianni et al.(2016)interviewed more than 200different manufacturing SMEs in north part of Italy which concluded that beside the economics issues, informational and behavioural barriers emerge as critical issues.

Viesi et al. (2016) has found that requisiteassurance from higher management isalso key barrier in SMEs leading to a littleurgency of energy efficiency improvement measures, consideration of the same should be taken into account during policy design.Top management functional role and operational managers involvement also plays a significant role in implementation of the energy efficiency improvement projects. The involvement of top operational managers in executionof any type of energy efficiency enhancement projects increase the likelihood of adaption from 31 % to 44% (Blass et al., 2014).

Harris et al. (2000) has found that the investment in energy efficiency improvement projects in Australian organizations is a complex issue. The investment decision depends upon a large number of factors and the major barrier for this type of investments is the expenses and involvement of various risks in attaining information and investment in new technologies.

A study of residential, commercial and industrial sectors in India found that the key barrier to energy efficiency improvement were (i) lower awareness; (ii) capital expenditure; (iii) availability constraints; (iv) undefined monetary benefits or savings; and (v) unconcerned consumers. As a measure for the removal of major barrier government should try to disseminate the monetary benefits related information to the consumers and easy understanding of the trade-off between the investment cost of the energy efficient device and the forthcoming energy savings (Reddy and Shrestha, 1998).

Many studies have found various barricades related to implementation of energy efficiency improvement in engineering and manufacturing sector. Still, there is no agreement about the most important barriers. Different authors have defined different barriers as critical barricades for the energy efficiency improvement initiative. While some of the authors such as Nagesha and Balachandra (2006) and Rohdin et al. (2007) determined that economic barricades are the utmost substantial barriers, others have recognized production related risk and information barriers as the key important barriers (Kounetas et al., 2010; Rohdin and Thollander, 2006). A study of the US based cement manufacturing organization found that involvement of large capital investments act as a hinderance in energy efficiency improvement measures (Coito and Allen, 2007).

Subsequently, there is uncertainty, whether overcoming the most critical barricades will automatically lead to improved energy efficiency implementation, specificallyin case of inter-relation of barriers.Worldwide, A number of policies have been deployed for the promotion of the energy efficiency in different sectors but there is no conventional methodology or theory on when and which policy should be applied to get the full utilization of the promotion activities(Chai et al., 2012).

Conclusion

To endorse energy-efficiency developments, actions are expected at one or more levels -- from the lowest level of the consumer (commercial, industrial and residential) to the highest level of worldwide agencies. However, barricades to the execution of energy-efficiency enhancements projects exist or can arise at all these levels.

In literature several barricades to the implementation of energy efficiency technologies have been recognized and different techniques and policy instruments have been presented to provide a solution for these barriers such as mitigation of risk can be addressed by different essential grants and loan facilities, rebate or subsidies, tax deduction, tax credits etc.Similarly, information problem can be resolved through different type of energy audits, product labelling under standard and labelling scheme, energy performance certificates of different appliance, building codes, grants and loan facilities and guarantees(Cattaneo,2019)

The number of times imperfect information appeared in the literature advocates that firms would have additionally participate in energy efficiency improvement projects if these firms were well conversant with the prospectsaligned and subsequent reimbursements or payback. Corollary to which, disseminationof energy efficiency improvement programmes isconsidered as a priority to reduce the impact of the barrier. Kostka et al. (2013) suggested that the informational barriers are the major blockage rather than financial and organisational barriers.

Some authors have proposed the system thinking approach for the barriers by using (MCIR framework) four stages, motivation, capability, implementation and result as well as feedback loop. The system solution is proposed with the consideration of relationship between the barriers, which permits the valuation and identification of the feeble link in energy efficiency policies (Chai and Yeo, 2012).

We have seen that the classification of the barricades to energy efficiency are diverse for different firms or establishments. Some barricades are very substantial in majority of the industrial establishments (financial/capital related, informational) while position of furtherbarricades differs considerably across sectors. Therefore, practical policy solutions need to address the specificenvironments of energy-using sectors and organisations. So those targeted barriers can be overcome by the utilization of the adopted policy measures. However, it is highly unlikely that there will be a possibility of single best policy solution for all of the barricades. As an alternative, a variety of approaches is likely to be required, which will be helpful for the addressing the barriers of individual circumstances.

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