CHAPTER - 2
LITERATURE REVIEW

2.1 INTRODUCTION
This chapter presents the selected literature pertaining to energy consumption, energy efficiency, environmental aspects, and factors influencing energy efficiency, and the barriers & drivers to energy efficiency. These literatures are provided to bring out the relevant research studies and approaches in order to attain energy efficient industrial setting. Further, towards the end some research gaps are also identified which helped in framing the objectives of this research work.

2.2 NEED FOR ENERGY EFFICIENCY IN INDUSTRIES
Energy is a key input in every sectors of an economy. Though all the sectors consume significant amount of energy in an economy, Industrial sector has emerged as the largest consumer of energy in industrialized countries (Murgatroyd, W, 1980). Developing countries and transition economies like India, account for more than 2/5 of the total energy consumption (Reddy and Balachandra, 2003). The industrial sector also comprises micro, and small-scale industries apart from medium and large-scale industries in a country and they meet various socio-economic objectives.

Among the developing countries India has a unique place in promoting MSMEs as it assigned a strategic role to this sector by introducing public policies and targeted efforts for their development. India has a competitive advantage in the MSME sector because of availability of skilled labor at competitive wages, entrepreneurship skill, and availability of raw material. However, increased economic activity calls for amplified energy consumption which in turn leads to more negative environmental implications, thus challenging the sustainable development. These small industry units are generally set up by one or two persons, these firms essentially rely on the entrepreneurial skills for survival and growth and they are usually located in clusters. According to UNIDO, a cluster is a sectoral and geographical concentration of enterprises, in particular small and medium enterprises, faced with common opportunities and threats which can:

- Give rise to external economies (e.g. specialized suppliers of raw materials, components and machinery, sector-specific skills, etc.)
- Favor the emergence of specialized technical, administrative and financial services
• Create a conductive ground for the development of inter-firm co-operation and specialization as well as cooperation among public and private local institutions to promote local production, innovation and collective learning.

Clustering of similar or related firms helps in generating localized external economies that lower the cost for producers. Such advantages include a pool of specialized workers, easy access to specialized input suppliers & services, and quick dissemination of new knowledge. In addition to incidental external economies, there is often a conscious pursuit of joint action. The uniform distribution and growth of this sector besides resulting in preponderance of self-employment and under dispersal of industrial and economic activities, ensures maximum utilization of both human and material resources. MSMEs in India are generally considered less efficient in material & energy use compared to larger enterprises and enterprises of similar scale in developed countries (TERI, 2001). Today, MSME in India finds itself in a competitive environment and enhancement of its competitiveness is considered crucial for its survival and growth (Bala Subrahmanya, 2004). Thus, improving energy efficiency, particularly in energy intensive MSMEs help not only in enhancing their competitiveness through cost reduction but also aids in reducing the negative environmental implications linked with energy use. Energy efficiency improvement in MSME clusters will have multiple benefits like:

- Demand for energy supply will grow at a lesser rate.
- Saved energy can be made available for other economic activities.
- Reduction in per unit cost and thereby making the concerned sector more competitive.
- Reduction in negative environmental impacts.

An industrial plant can be viewed simply as a system to which raw material, energy and labour are provided and from which material goods, waste materials and always waste energy are obtained. The waste energy is generally heat energy that is rejected to the surroundings because of the cyclic nature of many plant processes. It is worthwhile from an energy and cost saving view point to minimize the heat actually rejected to the atmosphere. Disregarding the complexities of the technological system employed and the physical nature of the plant, the industrial process can be represented in terms of energy and flow of materials as shown in a simplified Figure 2.1.
Industrial energy conservation includes using energy more efficiently and producing more efficient goods and services (Hu, 1983). The MSMEs constitute a major portion of the industrial sector in both developed and developing economies and generally use excessive energy and generate pollutions, causing environmental degradation (Visvanathan and Kumar, 2002). In this backdrop, contribution through promotion and increase of energy efficiency in the industrial sector comprising MSMEs assumes importance considering its significant share in world energy consumption. Hence improvement of energy utilization efficiency in the MSME sector is vital for reducing energy intensity. In this sector of energy consumers, much more often, a lack of information, motivation and know-how, financial restrictions as well as technology deficits and market imperfections result in an insufficient degree of rational use of energy. These untapped potential will represent win-win constellations of a market for cost-effective energy services and lower energy costs.

Energy efficiency is often broadly defined by the simple ratio of “useful output of a process” to “energy input into a process”. Energy efficiency is measured by the first law of thermodynamics. The first law indicates that energy can be neither created nor destroyed; it can only be changed from one form to another. Therefore, if we neglect the chemical conservation of energy into mass or vice versa, the net increase in the energy content of a particular system in a given time interval is equal to the energy content of material leaving the system plus the work done on the system and the heat added to the system. Thus, one can increase energy efficiency by reducing heat loss and heat discharge or increasing heat transfer and work rate (Hu, 1983). Figure 2.2 shows this energy flow in a typical device.
Energy Intensity (EI) is often used as a measure of the efficiency with which energy resources are being used. According to Hepbalsi and Ozalp (2003), there are two factors that should be taken into account by an industrial organization to go for improving energy efficiency. First, additional profits can be created by improving energy efficiency. Second, saving energy has a significant impact on the environment, since improved energy efficiency is one of the quickest and most cost effective responses to the threat of global warming.

When these MSMEs cluster in a geographical location, specifically energy intensive ones, the quantum of total energy use and its associated environmental implications assume sizable proportions. Further, such an industrial clustering in developing countries, including India, is significant and is also common in a wide range of sectors. According to UNIDO, there are about 400 Small Industry Clusters and 2000 rural & Artisan-based clusters in India. According to Small Industry Development Organization (SIDO) these clusters contribute about 60% of manufactured national exports and account for a significantly high share in employment generation. MSME sector, being a vital component of Indian economy is also a major consumer of energy input. Even if the energy use by an individual unit is trivial, the total consumption by the MSME clusters and the sector as a whole is likely to be of sizable quantum in view of the large number of MSME units and clusters operating in the country. Several of these clusters coming under Iron & Steel, paper & Pulp, Cement, Textile, Brick and Tile, etc., are considered energy-intensive.
2.3 ENERGY CONSUMPTION AND EFFICIENCY ISSUES IN MSMEs

Activities to promote and increase energy efficiency in the end use sector are an important contribution to the achievement of energy conservation and environmental protection goals. In industry, an extensive array of options can be found enabling further reductions of energy consumption and CO₂ emission. This is particularly true for MSMEs, which contribute significantly to Indian economy in several ways, and consume significant amount of energy. But they are found wanting in energy utilization efficiency and environmental aspects like pollution control (LUS, 1997). Thus, of late, energy consumption and efficiency issues of MSMEs have been attracting the attention of researchers; the constraints for efficiency have been identified in some sectors and recommendations made accordingly for energy efficiency improvements. Thus, the objective of this section is to highlight briefly some of the energy related studies undertaken so far in the context of MSMEs.

In view of the growing significance of MSMEs in energy and environmental issues, Asian Institute of Technology (AIT), Bangkok conducted a study to develop a framework of policy instruments and strategies needed to promote energy efficient and environmentally sound technologies in China, India, Philippines, Sri Lanka and Vietnam for the desiccated coconut, foundry, tea, textile, and brick and ceramic sectors. The study found that though the MSMEs are not major polluters in most sub sectors, they often pollute more per unit compared to large scale industries. With the revealed evidence of increasing energy consumption and consequent pollution, there is a need for governments to address environmental protection and energy conservation as two important and integrated areas. Therefore, the study advocated the promotion of environmentally sound technologies as the suitable options where both savings in energy input and reduction in emission to the atmosphere are simultaneously achieved (Visvanathan and Kumar, 2002).

Perhaps, the maiden study related to energy aspects of MSMEs in India was conducted in the grain mill sector of Karnataka State (Ramachandra and Subramanian, 1993). It analyzed energy utilization in detail by calculating Specific Energy Consumption (SEC) and Energy Intensity (EI) for all the selected firms. The wide disparity in SEC and EI values indicated large non-uniformity of energy use efficiency. The study found capacity utilization, quality of energy and production volume influenced the SEC in those firms. The study estimated a potential energy saving of 23-38% by shifting of lower production
range industries to higher production range so as to make use of installed capacity optimally.

Studies conducted by Development Commissioner of Small Scale Industries (DCSSI) on 80 small-scale ceramic tableware units in Khurja, Chinhat and Gujarat, revealed that energy constitutes about 40% of production cost. The study suggested various short and medium term measures for saving energy in the ranges of 1 to 15%. With long-term measures such as redesign/replacement/modernization of technology of kilns, saving in the range of 20 to 40% was found achievable (DCSSI, 1997a). The DCSSI study in 80 small-scale glass production firms in Ferozabad, Shikohabad and Varanasi, found energy constituting 25 to 29% of total production cost with 95% of total energy consumed in the furnace itself. The SEC levels ranged between 20.5 to 92.6 MKJ per MT of glass draw. A significant energy saving potential existed through adoption of suitable conservation measures such as proper insulation (20% saving), recovery of waste heat (25-30%) and fuel switching (DCSSI, 1997b).

The Energy and Resources Institute (TERI) study conducted at Noida identified plastic & rubber, fabrication & machining, and textile as three most energy-intensive sub-sectors. By conducting energy audits, scope for energy saving was found in motors, boilers, compressors, cooling towers, lighting etc. The study felt that MSMEs may not consider energy saving options purely on economic benefits but it must be promoted along with other concerned issues (TERI, 1998). TERI also conducted a detailed ‘Action Research’ on foundry clusters at Agra and Howrah. The energy audits conducted at Agra revealed a very low operating efficiency of cupola characterized by very high coke feed ratio. The study estimated an energy saving possibility of about 40% via better working procedures and improved furnace designs. In the Howrah cluster, cupola design was improved for further energy saving and reduced pollution levels (TERI, 1999). Further, TERI also conducted studies in MSME sector to improve the efficacy of its various initiatives related to energy-efficiency (TERI, 2010).

A study of energy consumption in MSME clusters in Karnataka has identified labour skill levels, owner qualifications, and technology levels as the important factors in explaining the energy consumption and environmental impact. (Bala Subrahmanya and Balachandra, 2002). As energy makes a substantial contribution to output in many MSME clusters, there
is a need for firms in the clusters to adopt energy efficiency as a ‘cost cutting’ or ‘profit maximizing’ strategy. The government intervention for achieving higher energy efficiency is advisable in the national interest and may be achieved through awareness campaign, upgradation of technology, improvement in skill level of human resource, etc. (Bala Subrahmanya and Balachandra, 2003).

But, it can be noted that most of the initiatives to improve energy efficiency and environmental performance in MSMEs have adopted a technocratic approach. Observing that such initiatives have achieved little in India, in terms of efficiency improvements or environmental improvements, Dasgupta (1999) argues that these initiatives suffer from narrow perspectives and inappropriate methodology. Combustion related pollution is closely related to several factors such as inefficient resource use, absence of waste management, poor work practices and house-keeping. Such factors must be addressed first, to prepare the ground for technological change and any energy-led initiative must consider them necessarily.

2.4 SMALL INDUSTRY CLUSTERS ENVIRONMENTAL POLLUTION

Most environmental problems that confront mankind today are related to the use of energy. Degradation and low accessibility of water resources, industrial pollution, and urban congestion are the major environmental issues that deserve high priority for India, besides land and soil resources and deforestation (UNEP, 1997). Awareness of the environmental effects of energy production and its use in the transport, industrial, and domestic sectors is on the rise. Concern over environmental degradation brought about by increased consumption of fuels such as coal and oil has been growing. Combustion of fuels in the industrial and transport sectors is the major source of emissions, but domestic sources also pose potential health hazards (TEDDY, 2003).

Though industrial pollution is considered a serious threat to the environment, the significance of MSMEs within this segment is generally ignored. However, due to their large population and higher pollution intensity MSME sector cannot be overlooked (CPCB, 2002). MSME is promoted through policy intervention by governments in developing countries like India to achieve multiple objectives such as employment generation, export promotion, balanced regional development, entrepreneurship creation, etc. Today MSME is a consistently growing sector in Indian economy and pollution
caused by them is going to be a major problem (Kuik, et.al, 1997). But clusters offer scope for better enforcement of environmental regulations as well as joint action by clustered firms for setting up common effluent treatment plants or knowledge sharing etc.

Kennedy (1999) has brought out that collective action by tanners located in the Palar Valley of Tamil Nadu has enabled them to meet the “Pollution Crisis” successfully. In the Palar valley alone, about 45% of India’s leather is produced by more than 200 tanneries. In 1995, the Supreme Court of India ordered the closure of hundreds of tanneries in Tamil Nadu for failing to treat their effluents. With their survival at stake, local producers of Palar valley opted overwhelmingly for a collective solution and took immediate steps to form Common Effluent Treatment Plants (CETPs). Thus, collective action enabled local producers to meet effectively the challenge of pollution control. But this collective action emerged due to external threat rather than internal realization.

The same is true in the case of lead smelting units in Calcutta. Lead Smelting units are considered one of the most air polluting sub sectors in Calcutta (Dasgupta, 2000). The owners were little educated and poorly informed. They were not aware that reducing furnace inefficiency would reduce cost of pollution abatement. They did not understand the technical specifications and implications of pollution standards either. But, when this cluster of units was threatened with closure and offered assistance by the local environmental agency, these units took steps to comply with the environmental standards. Within one year, they improved their work practices, introduced waste management techniques and reduced furnace inefficiency with the assistance got from the State Pollution Control Board.

Bartone and Benavides (1997) through their four case studies pertaining to Mexico, Peru, India, and Zimbabwe ascertained the problems associated with hazardous waste management in MSMEs. They suggested that steps to improve environmental management in MSME must include a combination of information and educational campaign to address the limited knowledge base and low environmental awareness in the sector.

Ghose (2001) is of the view that all industrial activities have adverse impact on the
environment, but a few sectors of MSMEs have major impacts and the industry has found it difficult to mitigate these adverse impacts. Some of the environmentally problematic sectors of MSMEs, according to him, are Tanneries, Pharmaceuticals, Chemical processing, Pulp and paper, Textile dyeing and Printing, Dyes and Dye, Metal Finishing, Foundries with Cupolas, Brick Kilns, Lime Kilns, Stone Crushers, Food and Fruit Processing, and Metal Processing.

All the above literature brings out that micro small and medium firm of certain industrial category do cause environmental damage through air pollution, particularly those located in clusters. MSME clusters, in general, lack the knowledge base and also the awareness to implement pollution prevention plans. Even if a particular small firm is interested in implementing any of the changes required to become more environment friendly, it lacks the capital resources to do the same. However, in none of the clusters, small firms on their own have initiated joint-action to reduce pollution. It is either due to the threat of legal action towards closure or assistance offered by some external agency for improvements or a combination of both that small firms in clusters have joined together to incur costs to counter environmental pollution and realized ‘benefits’ subsequently. The task is arduous. Thus, mere technological approach will not be sufficient to alleviate environmental pollution in small-scale industries. Along with identification of constraints and incentives to adopt environmental pollution abatement measures, it is essential to investigate the socio-economic and regulatory environments in which small firms operate, as well, as there is a need to convince the MSME entrepreneurs about the need to go for environmental protection.

2.5 ENERGY AND ENVIRONMENTAL ISSUES IN BRICK INDUSTRY

There are a few studies regarding energy and environmental issues pertaining to brick manufacturing units. The Bureau of Energy Efficiency (BEE, 2010) carried out studies in the brick cluster of Varanasi. Based on the energy audits, their recommendations made in the cluster include:

i) Process change from straight line to zigzag firing,

ii) Adoption of best practices in coal charging/feeding,

iii) Adoption of induced draft fan, and

iv) Shifting to VSBK and Hoffman Kiln.

The Greentech Solutions (Greentech Knowledge Solutions, 2012) aimed at developing strategies for the introduction and promotion of cleaner walling materials in India, thereby
recommending that the efforts to propagate cleaner brick kiln technologies over the next
decade should focus on three specific technical measures:

a) Adoption of cleaner kiln technologies,

b) Promotion of internal fuel in brick making by mechanizing the brick making
   process,

c) Diversifying products (e.g. production of hollow and perforated bricks) and
   promotion of modern renewable energy technologies in brick making.

(Nagesha, 2010), (Nagesha and Bala Subrahmanya, 2006), and (Bala Subrahmanya and
Balachandra, 2002) have identified labour skill level, owner qualification and technology
level as the important factors in explaining energy use and environmental pollution in the
Indian context. However, (Blackman and Geoffrey, 1998) found that small-scale brick
makers in Ciudad Juarez, Mexico have responded significantly to informal community
pressure for improved environmental performance. Further, Blackman (2000) has
developed a list of feasible environmental management polices and examined how these
polices have fared to control emissions from informal kilns in northern Mexico. Till
recently, there was hardly any reference made either in government reports and documents
or in research literature, to the environmental implications and impact of small scale brick
industries with reference to south Indian clusters.

Keeping in line with the rising emphasis on climate change related concerns nationally and
internationally, the National Action Plan on Climate Change (NAPCC) was introduced in
2008 and outlines the existing and future policies and programs addressing climate
mitigation and adaptation. Two out of the eight missions could be relevant to the brick
sector - The National Mission for Sustainable Habitat which aims to make habitat
sustainable through improvements in energy efficiency in buildings among other
measures. With growing environmental consciousness at all levels of society, the pollution
caused by the brick industry is under the scrutiny of environmentalists and the
government. The government of India took a step towards controlling environmental air
pollution from brick kilns by issuing a notification on emission standards for brick kilns in
April 1996. An industry over a period of time could cause significant damage to the
surrounding environment and ecological features due to the cumulative emissions or
industrial waste generated in the zone. Industries are, therefore, required to be sited,
striking a balance between economic and environmental considerations.
To prevent air, water and soil pollution arising out of industrial projects, regulations require entrepreneurs to obtain clearance from Central/State Pollution Control Boards before setting up the industry. The State Pollution Control Board is responsible for granting the Consent to Operate (No Objection Certificate: NOC) to brick production units. Usually, there is a separate application form, set of guidelines and other requirements for each category of unit and the brick industry falls under the red category. The NOC is in keeping with the provisions of the Water (Prevention and Control of Pollution) Act, 1974 and Air (Prevention and Control of Pollution) Act, 1981. Industries falling in the Red category – such as brick producing units are required to renew their consent to operate certificate every year. Further:

- Such industries should not be established on prime agricultural lands and forest lands
- They must be located at least 0.50 km away from the National and State highways, high tide, lines, flood plains, villages and small settlements and 2 km away from the outskirts of small towns with population of 50,000 or less, and 5 km away from the outskirts of large towns with population of more than 50,000.
- Enough space should be provided for storage of solid wastes so that these could be available for possible reuse.

Central Pollution Control Board (CPCB) has recognized the brick production industry as a highly resource and energy intensive and polluting industry owing to prevalence of obsolete production technologies. While, the clusters are the source of local air pollution affecting local population, agriculture and vegetation; at a global scale they also contribute to climate change. The brick industry competes for resources with other sectors, which poses a significant challenge to the sector. Coal is one such resource that is required for the power, steel and other crucial sectors. Also, top soil or land which could be used for agriculture. The traditional kiln unit itself occupies considerable land area and is subjected to high temperature making it unfit for agricultural activities. The fast depletion of arable land thus caused due to brick making is a matter of concern to India regarding food security. The large coal consumption of the brick industry is the cause of significant air pollution in terms of carbon dioxide (CO₂), carbon monoxide (CO), sulphur dioxide (SO₂), nitrogen oxides (NOx) and suspended particulate matter (SPM). The large amounts of coal used for brick firing also leave behind bottom ash as residue. The air pollution and bottom
ash generated causes considerable health problem, especially related to respiratory health, while also causing damage to property and crops.

The Supreme Court of India issued a directive for discontinuing the movable chimney kilns and for all brick kilns to conform to new environmental norms. While this signaled a move in the right direction, due to slack monitoring mechanisms such kilns continue to function and flout environmental regulations. Additionally, while kilns with higher production levels and capital have the option to changeover to fixed chimney type like Bull’s Trench Kiln (BTKs), the small and medium scale brick entrepreneurs are confronted with environmental regulation without having financially viable options to switch and thus continue to run polluting kilns.

2.6 FACTORS INFLUENCING ENERGY EFFICIENCY AND MSMEs SUCCESS

There are some previous studies of the factors contributing to energy efficiency. For instance, Baranzi and Giovannini (1996) links energy consumption to four major factors viz. technological, economic & financial, institutional, and cultural. They observe, technical factors based on energy using equipment and economic & financial factors in terms of income & relative energy prices have attracted much attention in the past. Further, they feel institutional factors comprising information campaigns, infrastructure, property rights, etc, and cultural factors involving attitudes, behaviors, lifestyles, etc, must be understood better for significant improvement of energy efficiency. Another study conducted by Kiel University (University of Kiel, 1998) on Micro Small and Medium-sized Enterprises of certain European countries stresses organizational and behavioral aspects of MSMEs in achieving energy efficiency. Dasgupta (1999), after analyzing some initiatives of energy efficiency and environmental improvements in Indian small scale industries, she emphasizes the need to address other non-technical factors associated with energy efficiency such as resource use efficiency, waste management, poor work practices, layout and house-keeping, etc. Bala Subrahmanya and Balachandra (2002 & 2003) have analyzed energy consumption and environmental pollution of a few small scale industry clusters in Karnataka from a managerial perspective. They have identified labour skill levels, owner qualifications, and technology levels as the important factors in explaining the energy use and environmental pollution.

The following studies based on surveys have dealt with the factors affecting micro, small
and medium enterprise success. Chittithaworn et al (2011) explored the business success factors of MSME in Thailand, based on a survey. They examined eight factors which are MSMEs characteristic, management and know-how, products and services, Customer and Market, the way of doing business and cooperation, resources and finance, strategy, and external environment. They found some variables significantly affect business success, which included MSMEs characteristics, customer and market, the way of doing business and cooperation, resources and finance, and external environment. Saleem (2012) investigated some socioeconomic factors like age, education, experience, skills on the success of small business. He found investment, business profile; entrepreneur experience and culture are significant for the success. There are many other empirical studies which examined success factors in MSMEs (Helsinki 2010; Syed Wajahat Hussain Naqvi 2011; Md Reaz Uddin 2013). Their findings suggest that customer service, know-how of the business and the past experience of the managers are the key factors leading to the success.

The success of MSMEs depends on number of factors which are multidimensional. Some factors are internal and some are external. Though both of them affect the success, there is considerable variation in between them as identified by previous studies. An extensive literature survey by Rogoff et al (2004) found that internal and external factors are determinants of business success. The former refers to the characteristics of the owner or entrepreneur and business; while the latter deals with factors beyond the control of the owner. Among other internal factors are size and years in business, the ability to attract outside capital investment, management, financing, planning, experience, and skill to implement any identified projects. The external or environmental factors are sales tax rates, infrastructure expenditure, university research, corporate debt, credit market condition, business opportunity, availability of resources, economic conditions, competition, and government regulation. After examining several internal and external factors affecting growth of firms, Tan and Tay (1994) asserted that financial assistance provided by the government, prior experience of the entrepreneur, quality product, and good customer service contribute positively and significantly to the growth of small enterprises. In a similar study by Yusuf (1995), good management, access to financing, personal qualities and satisfactory government support were perceived to be the four most critical success factors in small business. Further, Phetphairin Upping (2013) indicates the main external factors are government policy and network whereas the internal factors
indicate that family group management, strong leadership, and professional skill of members are key success factors for product development success.

Through the review of literature it may be concluded that energy efficiency and firm’s success depends to a large extent on the existing company culture, and on the engagement of firm internal key actors and their interaction within the organization. Furthermore, the findings underline the paramount importance of external actors to trigger energy related activity in MSMEs and to foster a lasting implementation of efficiency measures, which points at promising domains for policy intervention. An understanding of such factors would enable public policy makers and small business advisory to serve better in the small business sector.

2.7 BARRIERS AND DRIVERS TO ENERGY EFFICIENCY

Despite the need for enhancing industrial energy efficiency, studies indicate that cost-efficient energy conservation measures are not always implemented, implying the existence of an ‘energy-efficiency gap’. The energy-efficiency gap is in turn explained by the existence of barriers to energy efficiency by SPRU (2000), Hirst (1990), Reddy AKN (1991), and Weber (1997). Understanding the barriers that prevent industries in enhancing energy efficiency measures is important to help overcome the gap. A gap that needs to be shrunk, not only for economic but also for environmental reasons.

Several empirically studies have already investigated barriers to energy efficiency. Golove and Eto (1996) have discussed in detail the market barriers to energy efficiency and the rationale of public policy intervention to improve energy efficiency in different economic sectors. DeCanio (1998) investigated the barriers using a case study from a voluntary pollution prevention program implemented by US Environmental Protection Agency found that economic forces are important factors in energy efficiency investment, while organizational and institutional factors are also playing major roles in firms’ investment behavior. De Groot et al (2001) have done a case study in nine different Dutch industrial sectors to determine the behavior of firms towards investment in energy efficiency and their responsiveness to various energy policies. Rohdin et al (2006) and Thollander et al (2008) have explored the barriers to and drivers for energy efficiency in the Swedish industry. In these studies the barriers are classified into three major categories, which are: economic barriers, behavioral barriers, and organizational barriers. Using the interpretive
structural modeling, Wang et al (2008) have depicted the interrelation between the barriers to energy efficiency in China by investigating 13 different barriers. There are a few regional studies on this subject, such as the work by Thiruchelvam (2003), which shows the obstacles faced in adaptation of energy-efficient and environmentally sound technologies in small- and medium-sized industries in the five Asian countries: China, India, Sri Lanka, Philippines, and Vietnam. There are also a few technology specific studies regarding this aspect. Sola (2007) have shown how the organizational human factor can affect the energy efficiency in an electrical motor system in Brazilian industry.

While analyzing the drivers is vital in improving the energy efficiency, it is also important to understand what drives industries to increase energy efficiency. Drivers for energy efficiency are a relatively new research field since it has previously been assumed that economic reasons are the only main drivers. However, the barrier theory has proven that behavioral and organizational factors often hinder investments in energy efficiency. Thus, they can also drive the undertaking to increased efficiency if properly identified. Previous empirical studies have illustrated the importance of public policies and organizational and behavioral driving forces as well as external driving forces for implementing cost-effective energy efficient energy technologies. Nevertheless, previous research has found that not only cost reductions, resulting from lowered energy use are of importance, but other factors such as a decrease in technology price levels, awareness, environmental regulations, committed energy manager engaged in energy questions at the industry and threat of raising energy prices may also be of crucial importance.

There are quite a few other studies on drivers and barriers in the industrial sector, particularly in the energy-intensive foundry, and iron and steels. They include Rohdin (2007), and Zhang (2008). There are also useful research studies in other manufacturing and non-manufacturing sectors such as Sorrell (2000), Nagesha (2006), and Massoud (2010) including the proposal of policies for the industrial energy efficiency enhancements Levine (1994), and Reddy (1998). In developing countries, energy policies have been directed more at promoting overall macroeconomic growth than coping with or alleviating the adverse environmental problems that may result from energy use (Abdalla, 1994). Efficient use of energy does not seem to have attracted the attention of policy makers significantly yet, in these countries.
How to overcome these different kinds of barriers to achieve energy efficiency is a major challenge to the policy makers in general and particularly in the developing world. But, if any strategy has to be developed to promote energy efficiency in any sector by overcoming these barriers, the pre-requisite is to understand the existing energy consumption pattern in the sector concerned along with the identification of factors, which act as barriers for energy efficiency improvement.

The literature review revealed that, most studies are intended to broadly evaluate the barriers that limit the industrial energy efficiency and design effective policies to tackle them. However, cluster-specific or industry-specific barrier related studies focusing on MSMEs are barely found in the literature. This underscores the need for regional and sector-specific studies in order to spot these barriers, and adopt effective energy policies UNEP (2006). In this backdrop, the current study aims to contribute through a study and analysis of barriers and drivers for the implementation of energy efficiency measures in three south Indian brick industry clusters.

2.8 SOME RESEARCH GAPS

Although some energy and environmental related studies of MSMEs are reported in literature from certain regions and sub-sectors of the country, there is still scope for further study. In India, the energy consumption by the MSME sector as a whole is likely to be substantial. However, small industry sectors have not succeeded in attracting researchers and policy makers in the past to the desired extent to study this vital issue. There is a need for increased industrial energy efficiency and better environmental performance of energy intensive small-scale industries. From the available literature pertaining to brick industries in southern India, the states of Karnataka, Andhra Pradesh, and Tamil Nadu appears not to have attracted the desired attention from researchers and policy makers in the past. Further, a detailed review of available literature on energy related studies in the context of Indian small scale industries has revealed the following:

1. Though it is appropriate to analyze energy consumption within its social context, most of the energy studies in the past have ignored the influence of some of the factors influencing energy and environmental aspects in MSMEs.
2. There is hardly any comparative study of different geographical small-scale brick production clusters substantially dealing with energy and environmental performance.
3. Most of the studies are either single cluster based or single industry focused and there is hardly any study of clusters comprising different regions of the country or involving drivers and sub sectors of the country.

4. There are very few cluster based studies substantially dealing with barriers and drivers to energy efficient improvement.

It is with these research gaps in mind that the current study is undertaken adopting an empirical approach in the three energy-intensive small scale brick industry clusters in south India. This study looks at energy efficiency from two different perspectives such as energy consumption, and environmental pollution. Apart from establishing the current levels of efficiency, it also finds the factors influencing the same. Further, estimating the energy conservation potential in the clusters, the relevant drivers and barriers are identified in order to fine-tune the policy initiatives for enhancing energy efficiency in the selected brick clusters. The improvement in energy efficiency is likely to contribute for the sustainable growth and development of this industry in the long run.