CHAPTER - 1
INTRODUCTION

1.1 PREAMBLE

Energy, the capacity to do work is critical, directly or indirectly, in the entire process of evolution, growth and survival of all living beings and it also plays a vital role in the socio-economic development and human welfare of a country. Energy as a resource is available in the nature in solid (coal, biomass), liquid (crude oil) and gaseous (natural gas) forms. Man cannot create energy; all that he can do is to convert it from one form to another. These resources are converted into a form desired by the end user, which can be broadly classified as electricity, coal and lignite, petroleum products, natural gas and non-commercial energy sources.

Environment comprises the biosphere, the thin skin on the earth's surface on which life exists, the atmosphere, the geosphere and all flora and fauna. These constituent parts of the environment interact with each other and may produce undesirable effects on the environment and in turn, on the human beings themselves. Pollution can be defined as an undesirable change in the physical, chemical or biological characteristics of land, air, and water that will waste or deteriorate raw material resources. Pollutants are byproducts of the high technological advancement and industrialization which has gripped the world and endangered the very existence of the organic world. Pollutants are of two kinds: (i) Natural pollutants, i.e., they arise from the nature, and (ii) Anthropogenic pollutants, which result from human activity. Natural pollutants rise from non artificial processes in nature, such as gases associated with the decay of animals and plants, particles from volcanic eruptions, salt spray from the oceans, and pollen. Anthropogenic pollutants are human induced and include all residuals associated with consumption and production. Examples include gases and particles from combustion and chemical wastes from certain manufacturing processes. Of these two, anthropogenic pollutants are of primary concern particularly those for which nature has little or no assimilative capacity (Callan and Thomas, 2000). Pollution harms human life, the life of other species, and also degrades living conditions and cultural assets, while wasting or deteriorating raw material resources. Thus, environmental pollution can be defined generally as the presence of matter or energy, whose nature, location or quantity has undesired effects on the environment.
Energy is not a commodity. It is the only essential stuff of life, hence is the most precious one. Since the day when man used fire for cooking, energy has played an increasingly pivotal role in his life. Gradually, man started multiplying the use of energy for the construction of shelter, fabricating implements, agriculture, transport, etc. Rapid increase in industrialization, coupled with higher growth rates in population, led to increase in energy consumption. But energy use is major contributor to localized and global pollution (Abdalla, 1994). The local pollution may be in the form of air pollution, water pollution, land pollution, and noise pollution. The global pollution, which is more significant than the other, may include acid precipitation, stratospheric ozone depletion and Green House Gas (GHG) emissions (Dincer and Rosen, 1998).

Energy is one of the important factors which can act as a constraint on economic growth of a country. The ever-growing world population is expected to get doubled by the middle of this century and almost every country across the globe is aiming for positive economic growth. This intensifying economic development across the globe is coupled with increased demand for energy. The developing nations of the world are largely expected to account for this increase in world energy consumption. In particular, energy demand in the emerging economies of developing Asia, which include China and India, is projected to more than double over the next quarter century. So, such a large scale consumption of energy is connected with significant negative environmental implications such as GHG emission, deforestation, loss of bio-diversity, resource depletion, pollution of water and soil, and waste disposal (Thiruchelvam, et al, 2003).

The Indian economy has experienced unprecedented economic growth over the last decade. The Gross Domestic Product (GDP) of India grew at 8.6% per annum in 2010/11, and targets of 8.2% and 9% per annum were set for 2011/12. This high order of sustained economic growth is placing enormous demand on its energy resources. The primary commercial energy consumption in the country for 2009/10 was around 316.29 million tonnes of oil equivalent (MTOE). With strong economic growth and rising energy consumption, India is now the fourth largest emitter of GHGs in the world, after the USA, China, and Russia (TERI, 2012).

India’s energy basket has a mix of all the resources available including renewables. The dominance of coal in the energy mix is likely to continue in foreseeable future. At present
India’s coal dependence is borne out from the fact that 54% of the total installed electricity generation capacity is coal based and 67% of the capacity planned for addition during the 11th Five year Plan period 2007-12, was coal based. Furthermore, over 70% of the electricity generated in India is from coal based power plants. Other renewables such as wind, geothermal, solar, and hydroelectric represent a 2% share of the country’s fuel mix. Nuclear energy holds a 1% share. Petroleum demand in the transport sector is expected to grow rapidly in the coming years with rapid expansion of vehicle ownership. While India’s domestic energy resource base is substantial, the country relies on imports for a considerable amount of its energy use, particularly for crude petroleum. Combustible renewable and waste constitute about one fourth of Indian energy use. This share includes traditional biomass sources such as firewood and dung, which are used by more than 800 million Indian households for cooking (Energy Statistics 2013).

Demand for energy in a growing economy stems from diverse sectors such as agriculture, industry, commerce, transport, and residential. Though all the sectors consume significant amount of energy in an economy, the sectoral energy use pattern of a country largely depends on its extent of industrialization and urbanization. Of the afore-mentioned major sectors, industrial sector is one of the largest energy consuming sectors of an economy. A review of literature shows that though industrial sector share in total energy use differs across the countries of the world, it is one of the largest energy consuming sectors of almost every significantly industrialized economy. Even in India the industrial sector remains the largest consumer of energy accounting for over 44% of total energy consumption. The transport and the residential sector in the second and third position followed by agriculture in the last position during the year 2010, as shown in Figure 1.1.
The trend in the growth of energy consumption by the various sectors of Indian economy in the past 30 years is depicted in Figure 1.2; here MTOE refers Million Tons of Oil Equivalent. This clearly establishes the need to focus on the Industrial sector.

The industrial sector is extremely diverse and involves a wide range of activities including the extraction of natural resources, conversion into raw materials, and manufacture of
finished products. Due to the wide variety of activities, energy demand and GHG emissions vary widely. The aggregate energy use and emissions depend on the structure of the industry, and the energy/carbon intensity of each of the activities. The structure of the industry may depend on the phase of the economic development, and many other factors like resource, and technology availability, as well as historical factors. Indian industries mostly rely on coal, oil and gas for primary energy. Amongst these, coal continues to be the dominant fuel. The industrial sector of Indian economy comprises a large number of Micro, Small, and Medium-sized Enterprises (MSMEs). A significant portion of MSMEs are engaged in energy and emissions-intensive activities in various sectors like metallurgical and metals industry, glass and ceramics industry, agro-based industries, brick-making, textiles, and foundries etc. In many of such MSMEs, energy is the most significant input and it accounts for as much as 30% – 40% of their total cost of production.

1.2 MICRO, SMALL, AND MEDIUM ENTERPRISES (MSMEs): AN OVERVIEW

1.2.1 Micro, Small, and Medium Enterprises
The Micro, Small, and Medium Enterprises (MSME) sector is of particular relevance in the developing world as they are considered as the engines of economic growth. In India, the MSMEs account for a lion’s share of total industrial units and the sector is of strategic importance in the economy in view of its contribution to employment generation, production, GDP, and exports.

Definition
There is no universal definition of MSMEs since the sector is diverse and flexible that resists any narrow categorization. There exist several definitions of the term small, micro and medium enterprises varying from country to country and varying between the sources reporting MSME statistics. The commonly used criteria at the international level to define MSMEs are the number of employees, total net assets, sales and investment level. Some countries use one criterion to define this sector while others may have definitions with multiple criteria. In the Indian context, according to the MSME Development Act of 2006 (a) a micro enterprise is one where the investment in plant and machinery does not exceed twenty five lakh rupees. (b) a small enterprise is one where the investment in plant and machinery is more than twenty five lakh rupees but does not exceed five crore rupees. (c) a medium enterprise is one where the investment in plant and machinery is more than five
crore rupees but does not exceed ten crore rupees. In the case of enterprises engaged in providing or rendering of services, as (a) a micro enterprise is one where the investment in equipment does not exceed ten lakh rupees, (b) a small enterprise is one where the investment in equipment is more than ten lakh rupees but does not exceed two crore rupees, (c) a medium enterprise is one where the investment in equipment is more than two crore rupees but does not exceed five crore rupees.

Table 1.1: Definitions of MSMEs in India (Source: UNIDO, 2004)

<table>
<thead>
<tr>
<th>Classification</th>
<th>Number of Employees</th>
<th>Manufacturing Enterprises</th>
<th>Service Enterprises</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micro</td>
<td>2-9</td>
<td>Rs. 2.5 million (Rs. 25 lakh)</td>
<td>Rs. 1 million (Rs. 10 lakh)</td>
</tr>
<tr>
<td>Small</td>
<td>10-49</td>
<td>Rs. 50 million (Rs. 5 crore)</td>
<td>Rs. 20 million (Rs. 2 crore)</td>
</tr>
<tr>
<td>Medium</td>
<td>50-249</td>
<td>Rs. 100 million (Rs. 10 crore)</td>
<td>Rs. 50 million (Rs. 5 crore)</td>
</tr>
</tbody>
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Importance of the MSME sector

The contribution of MSME sector to manufacturing output, employment and exports of the country is quite significant. According to estimates, in terms of value, the sector accounts for about 45% of the manufacturing output and 40% of the total exports of India. The MSME sector employs about 42 million persons in over 13 million units throughout the country manufacturing more than 6000 products, ranging from traditional to high-tech items. MSMEs generate new jobs in the economy and thereby positively contribute to employment generation and poverty reduction. Further, these enterprises require a relatively lower investment in capital compared to large enterprises. Therefore, MSMEs have a lot of relevance for economies like India, which are characterized by surplus labour and low investible resources. There are also some common features characterizing this sector. Generally, set-up by one or two persons these firms essentially rely on the entrepreneurial skills for survival and growth. Spatially they are dispersed all over the economy or located in clusters and they do not have a very formal and strict hierarchical structure (LUS, 2001).

MSME sector, being a vital component of the Indian economy is also a major consumer of energy. Energy represents an important and expensive factor of production for industrial
MSMEs particularly in energy-intensive sectors such as mineral processing (ceramics, tiles, pottery, brick, glass etc.), metallurgical and metal industries (foundries, forging, alloys, heat treatment, steel re-rolling, etc.) and agro and food processing (bakeries, dairies, rice mills, etc.). The MSMEs in these sectors currently use significant amounts of electricity as well as large quantities of fossil fuels (about 65 MTOE) and/or biomass to meet their thermal energy requirements. These fuels are often in the form of furnace oil, diesel, natural gas and coal or traditional biomass fuels to meet their thermal heat requirements. Highly energy-intensive industries like steel, paper and pulp, textile, cement, brick, and sugar etc., many of them operating in MSME sector cause both global and local pollution due to their inefficient energy use. Studies have shown that MSME firms not only produce more waste per unit of output but also, at an aggregate level, account for at least equal if not more pollution than their large-scale counterparts (Visvanathan and Kumar, 2002). There could be many reasons for this such as lack of awareness and information, financial and economic issues, structural and institutional aspects, policy and regulatory features, behavioural and personal attitudes concerning the sector. MSMEs, on their own, may do very little about energy efficiency due to these factors and moreover energy related issues might not be their priority while running the business. The MSMEs in these sectors largely depend on inefficient equipment and technology. This leads to wastage of fuel; it also results in release of substantial CO₂ and particulate emissions.

Overall, MSMEs mobilize local capital and skills, and thereby provide the impetus for growth and development, particularly in rural areas and small towns. They are often organised into clusters which are groups of similar industries within nearby geographical areas. However, MSMEs have fallen behind benchmarks in terms of productivity, technology and end use energy efficiencies compared to larger enterprises and enterprises of similar scale in developed countries. Recent steep increases in fossil fuel prices along with shortages of fuels/electricity and air pollution caused due to inefficient technologies are potential threats to the sustainability of energy-intensive MSME clusters in India. Today, MSMEs in India finds itself in a competitive environment and enhancement of its competitiveness is considered crucial for its survival and growth (Bala Subrahmanya 2004).
Though energy use and associated pollution from an individual firm is trivial, it assumes significant proportion at the cluster level, especially in a growing cluster, meriting serious attention (Nagesha, 2010). In order to bring about any substantial improvement on the energy front, a detailed understanding of present energy consumption pattern along with associated issues such as current level of energy efficiency, causes and consequences of it, conservation potential with constraints and motivators for its realization are essential. This has provided the inspiration to formulate this research study in the context of energy-intensive brick industry clusters.

1.2.2 MSME Clusters in India

A cluster may be defined as a local agglomeration of enterprises in particular MSMEs, faced with common opportunities and threats but often also including some large enterprises, which are producing and selling a range of related and complementary products and services (UNIDO, 2001). 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. Clusters can be primarily, of three kinds (UNIDO, 2001). (1) Horizontal Clusters: This type of cluster is characterized by units, which process the raw material to produce and subsequently market the finished products themselves. Majority of the clusters in India is of horizontal type (2) Large Unit Based Clusters: A cluster, which is established around a large unit or a few large units, is called a large unit based cluster. The relationship that exists between the small and the large units could be based on supply of some of the critical raw materials from large enterprises or on their working as subcontractors to the large firms, which means they are either backward linked or forward linked. (3) Vertically Integrated Clusters: In vertical clusters, the operations required in producing the finished product are divided and are carried out separately by different units, most of which are essentially MSMEs, in order to distinguish from the large unit based clusters.

MSMEs development in India is characterized, among others, by its concentration in different parts of the country in the form of clusters (Abid Hussain, 1997). The pull of the market, availability of physical and social infrastructural facilities, increased demand; raw material availability and skilled labour have contributed to this phenomenon (CPCB, 2002). According to a UNIDO survey of Indian MSMEs, there are 400 small and medium
industry clusters and approximately 2000 rural and artisan-based clusters. Majority of the clusters in India are naturally originated and belong to horizontal type. They constitute about 60% of the manufactured exports with a significant share in employment generation as well (SIDO, 2004). Knitwear cluster of Ludhiana, Gems & Jewellery clusters of Surat and Mumbai, Leather & Leather products cluster at Chennai, Agra and Kolkata, Blankets cluster of Panipat, Cotton hosiery cluster of Tiruppur, Sewing machine and Bicycle production cluster of Ludhiana, etc., are the best examples.

1.3 DEFINITIONS AND CONCEPTS

1.3.1 Energy Consumption, Energy Efficiency and Its Significance to MSMEs

Energy is required for survival of life (including human). Energy forms a central force to drive all the systems, either created by human or the natural systems that are linked to the human system. Energy is the capacity to do work. According to the First Law of Thermodynamics, the energy can be neither created nor destroyed, it can only change from one form to another (e.g. heat to light, chemical energy to electrical energy). The energy consumption poses a basic dilemma in achieving sustainable development in MSMEs. The total energy needs include both primary sources like biomass, coal, natural gas, etc., and secondary sources such as electricity, diesel, furnace oil, charcoal, etc. Energy consumption pattern refers to the share of various energy sources in the total end-use energy requirements. One can also express energy consumption in relation to specific parameters pertaining to an industrial firm like employment, investment etc. The study of consumption pattern helps us in understanding the relative importance of various energy sources and also guides the organization to improve the efficiency of resource utilization and finally leading towards competitiveness and sustainability of the unit.

Energy Efficiency (EE) is a generic term, and there is no one unequivocal quantitative measure of energy efficiency. Instead, one must rely on a series of indicators to quantify changes in energy efficiency. For example, in the industrial sector, energy efficiency can be measured by the amount of energy required to produce a tonne of product. Therefore, energy efficiency is often broadly defined by the simple ratio of “useful output of a process” to “energy input into a process” (Patterson, 1996). Given a measure of energy input, E, and a measure of useful output, O, one can define energy intensity, I, as I=E/O. Energy input, E, is often measured in thermo-dynamic units; useful output is often measured in either volume of output or market value of output. Thus, in general, energy
efficiency refers to reduction in energy intensity, which implies using less energy to produce the same amount of services or useful output. Understanding the pattern of energy consumption and probing the scope for reduction of energy intensity and improvement of energy efficiency in the MSMEs will have significant policy implications for economic development, as well as for the sector's own competitiveness enhancement. Thus improving energy efficiency, particularly in energy intensive MSMEs helps 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.

1.4 NEED FOR THE CURRENT STUDY

It can be deciphered from the table 1.2 that the number of MSMEs in year 2011-12 has shown growth rate of 19% which is approximately twice the growth rate recorded for previous years. Similarly, the state wise distribution of principal characteristics of MSME sector in the states selected for study is shown in table 1.3.

Table 1.2: Performance of MSME Units, Employment, Investments and Gross Output
(Source: Annual Report, 2012-13, Ministry of MSMEs, Government of India.)

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<tbody>
<tr>
<td>1</td>
<td>2008-09</td>
<td>393.70</td>
<td>881.14</td>
<td>971407.49</td>
<td>1524234.83</td>
</tr>
<tr>
<td>2</td>
<td>2009-10</td>
<td>410.82</td>
<td>922.19</td>
<td>1029331.46</td>
<td>1619355.53</td>
</tr>
<tr>
<td>3</td>
<td>2010-11</td>
<td>428.77</td>
<td>965.69</td>
<td>1094893.42</td>
<td>1721553.42</td>
</tr>
<tr>
<td>4</td>
<td>2011-12</td>
<td>447.73</td>
<td>1012.59</td>
<td>1176939.36</td>
<td>1834332.05</td>
</tr>
</tbody>
</table>
Table 1.3: State wise Distribution of Principal Characteristics of MSME Sector
(Source: Annual Report, 2012-13, Ministry of MSMEs, Government of India.)

<table>
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<tbody>
<tr>
<td>1</td>
<td>Karnataka</td>
<td>12.49</td>
<td>30.48</td>
<td>27161.11</td>
<td>56317.61</td>
</tr>
<tr>
<td>2</td>
<td>Andhra Pradesh</td>
<td>15.36</td>
<td>38.98</td>
<td>32757.63</td>
<td>58404.82</td>
</tr>
<tr>
<td>3</td>
<td>Tamil Nadu</td>
<td>20.55</td>
<td>53.16</td>
<td>77824.34</td>
<td>105270.21</td>
</tr>
</tbody>
</table>

Karnataka, Andhra Pradesh, and Tamil Nadu states, where the study clusters are located, are the pioneers in the field of industrialization in the country. The major industries operating in Karnataka are: information technology and software, machine tools, aerospace, electronics, precision engineering, telecommunications, minerals, silk, garment, pharmaceuticals and biotechnology. On the other hand, Tamil Nadu has a strong base of industrial sector in engineering, leather, mineral-based products, pharmaceuticals, cotton textiles & hosiery, wood products, agro & chemical based products and ready-made garments. The emerging industrial sector includes electronics, software, consumer durables, biotech products and rubber & plastics. Similarly the pace of industrial growth in the Andhra Pradesh state has quickened in the recent years and the focus is on development of key sectors like Pharmaceuticals, Biotechnology, Food Processing and Agro based, Chemicals, Leather, Textiles, precision components, Aero-space Engineering, Electronics and Semiconductors and Automobile & Auto components.

The MSME Development Act, 2006. Government of India have unveiled a policy best suited for the Micro and Small enterprises with the objective of achieving 15% annual growth rate, increasing employment generation, creating congenial and hassle-free environment, help the small and medium sector to acquire new technologies and skills, improve the export performance, and to promote linkage between the large and small sector. During 2012-13 the three states put together accounted for about 22.57% of enterprises, providing employment to around 24.50% involving an investment of 19.96 % in the national total. The three states not only have a substantial amount of MSMEs but also use huge quantity of energy in their production processes leading towards negative environmental impacts.
However numerous sector-specific studies have confirmed that energy intensity in MSMEs can be further reduced, with the widespread adoption of commercially available technologies to improve energy efficiency in process applications. Energy audits carried out in various MSME clusters under various UNIDO projects show that, in general, there exists a scope of 20-40% energy savings by shifting to energy-efficient technologies and reducing dependence on fossil fuels. Acceleration and scaling up of shifts to EE measures would bring about significant aggregate impacts and global benefits from reduced emissions of GHGs. In addition, MSMEs, especially like textiles, foundry and brick industries etc., those for whom energy costs represent a large portion of total production costs, can reap especially high direct economic benefits from improving efficiency. In today’s fiercely competitive liberalized economy, the survival of these MSMEs depends on their ability to cut fuel costs and improve profitability and environmental performance. This is particularly so in the light of the recent steep increases in fossil fuel prices and growing concerns over the environmental impact of CO₂ emissions.

1.4.1 Indian Brick Sector

The construction industry contributes to about 10% of the GDP, registering an annual growth of about 9%. The growth in the economy, population, and urbanization imply an increasing demand for residential, commercial, industrial, and public buildings and other physical infrastructure. Various studies indicate that, out of the total constructed area existing in India in 2030, about 70% will have been constructed between 2010 and 2030. Building construction in India is estimated to grow at a rate of 6.6% per year during the period 2005 to 2030. The building stock is expected to multiply five times during this period, resulting in a continuous increase in demand for building materials. The new construction will require building materials such as cement, brick, steel, stone, and sand in massive quantities. It is well known that building materials production processes are generally energy-intensive and have a large environmental footprint due to use of natural resources, as well as to emissions associated with energy use.

Bricks are one of the most important walling materials used in India. Clay fired bricks form the backbone of the construction industry which is valued at approximately US$ 70.8 billion. The brick sector in India, although unorganized, is tremendous in size and spread. India is the second largest brick producer in the world. It is continuously expanding on account of a rapid increase in demand for bricks in infrastructure and housing industries.
India has more than 100,000 brick kilns producing about 150-200 billion bricks annually, providing direct employment to more than 8 million workers. During the Ninth Five-year Plan period (1997-2002), the annual demand of 170 million bricks per year was estimated to be generating revenues of over US$ 4.8 billion. The percentage share of brick manufacturing in the world is illustrated in Figure 1.3.

![Share in world brick production](image)

**Figure 1.3: percentage shares in world brick production**  
(Source: Ecobrick, 2013).

Brick manufacturing industrial sector include mainly china, India, Bangladesh Pakistan and other countries. While china accounts for more than half of entire world production of bricks, India being is the distant second with a share of 11%. The sectoral contribution of brick industries in India are shown in Figure 1.4.

The figure makes it clear that north India has an overwhelming contribution to brick making in the country. Not only in northern parts of India even in south India also the brick industries are flourishing. This fact is further strengthened based on the data from literature, field visits, discussion with experts, media reports, and brick industry associations.
The brick industries are also flourishing in the Malur taluk of Kolar district in Karnataka state with more than 200 brick manufacturing units, Tiruvallur District of Tamilnadu state with around 150 brick manufacturing units, and surroundings of Krishna district in the state of united Andhra Pradesh with around 120 brick manufacturing units. The increase in number of enterprises in the information technology sector in Bangalore (Karnataka), Chennai (Tamilnadu), and Hyderabad (Andhra Pradesh) is also leading to generation of more employment and faster growth of economic activities. The growth in the economy, population, and urbanization in turn results in an expansion of construction sector. Further, since the bricks form the backbone of the construction industry a number of brick manufacturing units are flourishing in the surrounding regions with consumption of huge amounts of energy for firing the bricks in kilns. This is causing depletion of natural resources and leading to negative environmental impacts. Details of the brick making process and the types of brick kilns are provided in chapter 4 of the thesis.
Brick making in India is characterized by the following salient features:

- Brick making is a small-scale, traditional industry. Almost all brick kilns are located in the rural and peri-urban areas. It is common to find large brick making clusters located around the towns and cities, which are the large demand centers for bricks. Some of these clusters have up to several hundred kilns.

- The brick production process is based on manual labour, and brick kilns are estimated to employ around 10 million workers. Brick production is a seasonal vocation, as the brick kilns do not operate during the rainy season. Most of the workers migrate with their families from backward and poor regions of the country. Families, including young children, work in harsh, low paying conditions. There is typically a lack of basic facilities, such as access to clean drinking water and sanitation.

- 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 (after the site is abandoned). The fast depletion of arable land thus caused due to brick making is a matter of concern to India regarding food security.

- Bricks are fired to a temperature of 700 -1100°C, requiring a large amount of fuel for the firing operation. With an average consumption of 18 tonnes of coal per 100,000 bricks, the brick sector consumes about 24 million tonnes of coal per year. In addition, it also consumes several million tonnes of biomass fuels. The share of energy in total cost of brick production is 35-50 %.

- The large coal consumption of the brick industry is the cause of significant air pollution in terms of carbon dioxide (CO$_2$), carbon monoxide (CO), sulphur dioxide (SO$_2$), 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 problems, especially related to respiratory health, while also causing damage to property and crops.
Central Pollution Control Board (CPCB) has recognized the brick production industry as highly resource and energy intensive and polluting industry owing to prevalence of obsolete production technologies. While, the brick industry clusters are the source of local air pollution affecting local population, agriculture and vegetation; at a global scale they also contribute to climate change.

It is quite evident that the brick industry in India, particularly when seen in the light of future demand, could have long-lasting implications in terms of future energy demand, local pollution, contribution to GHG emissions, and the socio-economic conditions of a significant number of low-income workers. It is thus essential to provide them, reliable and cost effective energy in order to achieve ‘efficient growth’, of Indian economy. It is in this context that promotion of energy efficiency in this industrial sector assumes significance. This is particularly vital considering the fact that significant portion of the operating costs is in the form of energy costs. Therefore, energy conservation and management form a critical activity in reducing operating costs.

Apparently, there is an assumption that because they are small in size they cannot adversely affect the environment through their operations. The environmental effect of an individual brick making MSME may not be significant but their aggregate impact on the environment can be considerable, particularly when they operate in clusters, in certain locations. A significant number of units existing together in a cluster consuming substantial quantity of raw material and energy (coal, firewood, etc.) will be releasing various kinds of pollutants to environment. In addition, the production efficiencies (energy and material use efficiencies) are likely to be low in small scale units because of resource constraints. This further enhances the possibility of adverse impacts on the environment. Further, if these environmental impacts are due to either human errors or infrastructural inadequacies or obsolete technologies and if appropriate abatement measures (corrective actions) are taken, it will facilitate better environmental management and may even improve the economic performance of units and thereby enhance their competitiveness.

Despite its significance in the construction sector, importance in its large consumption of coal, and its impact on environment, the brick making sector has seen very few development interventions/programmes aimed at improving the industry. Additionally, there are not many studies in literature that comprehensively deal with the study of the
energy and environmental performance particularly in the south Indian brick industry clusters. It is in this context that the present study comprising three energy-intensive brick industry clusters with one each in the states of Karnataka, Tamil Nadu and Andhra Pradesh is undertaken with the following objectives:

1. To study the energy consumption pattern and associated environmental pollution.
2. To find out the current level of energy efficiency and estimate the potential for energy efficiency improvement.
3. To categorize and analyze the factors influencing energy efficiency.
4. To identify and probe the barriers and drivers to energy efficiency improvement.
5. To analyze the differences amongst the three clusters in terms of energy and environmental performance.

1.5 CHAPTER SCHEMATA

This thesis is organized in nine chapters. The second chapter reviews core literature pertaining to basic energy and environmental issues related to industry in general, MSMEs in particular, and identifies the research gaps. The third chapter comprises the objectives of the study, scope of research and methodology adopted for achieving the stated objectives. Background of the brick industry in India and the general features of the sampled units of three south Indian brick industry clusters pertaining to the study are presented in chapter four. Chapter five encompasses the energy consumption pattern and its implications for efficiency improvement and environmental pollution. Apart from finding the present energy efficiency levels and estimating the conservation potential, it includes the estimation of production function in establishing the importance of energy input. Chapter six analyses the factors influencing energy efficiency using a hypothetical framework pertaining to the three selected small industry clusters in this study. Chapter seven is devoted for recognizing and prioritizing the various barriers and drivers to energy efficiency enhancement in the three brick clusters. The comparison of the energy and environmental performance of the selected three brick industry clusters is performed in chapter eight. Finally, the concluding ninth chapter presents the summary of research findings and indicates policy implications for enhancing energy efficiency. The scope for further work in this area is also included.