The Benefits of Energy Efficiency in Small and Medium Enterprises

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Abstract. Small and medium enterprises (SME) play a major role in the economy of any nation. They are considered as the engines of economic growth. Their contribution to direct export has crossed 35 percent while indirect export is to the tune of 15 percent, recently. But, they are being threatened with closure due to higher levels of pollution. They lack cleaner production methods and increase in energy efficiency in SMEs not only reduces pollution but result in reduced costs. Energy management studies carried out in India and other countries are explored. It is found that SMEs/MSMEs activities contribute significantly to GHG emissions. The current manufacturing practices in MSMEs are analysed and compared with better practices found in the literature. It is found that there is a greater need for improving the energy efficiency. Cleaner production alongside technology up-gradation is found to be beneficial.

Keywords: SMEs, energy efficiency, GHG emission, technology up-gradation.

1. Introduction

Small and medium enterprises (SME) play a major role in the economy of any nation. They are considered as the engines of economic growth. They are often the main pillars an economy (Unnikrishnan et al. [51]). Their contribution to the nation’s gross domestic product (GDP) and amount of employment it generates are significant. Their contribution to the growth of large enterprises can’t be ignored.

The amount of employment generated through MSMEs rose from 805 lakhs in 2006 – 07 to 1171 lakhs in 2014 – 15. An increase of about 50 percent in nine years. The number of working enterprises
rose from 361 lakhs to 510 lakhs during same period. The contribution of this sector to the overall GDP is in excess of 36 percent during the same period. The share of MSME products in the export has reached a staggering value of 50 percent in 2015 – 16 MSME [33]. The direct export from this sector has crossed 35 percent while indirect export is to the tune of 15 percent.

In spite of the greater contribution of SMEs (MSMEs) to Indian economy, they are being threatened with closure due to higher levels of pollution (Dasgupta [9]). The large energy consumers have been the major contributors to this as it leads to negative environmental impacts. They lack cleaner production methods. Increase in energy efficiency in SMEs not only reduces pollution but result in reduced costs. Thus, there is a greater need for studying the SMEs in order to suggest adoption of modern technology for cleaner production and energy efficient consumption techniques (energy efficient and less pollutants emitting). This study explores the alternative approaches / methods of various industries in different countries.

Government of India has grouped the enterprises into clusters. Clusters are geographic concentrations of industries related by knowledge, skills, input, demand, and other linkages. In Karnataka, 19 clusters have been identified by the UNIDO (Godavari [18]. The better practices/methods are explored cost/saving and emissions are prevented.

2. Literature Review

The literature review is presented in three sections.

2.1 Growth and contributions of SMEs

India, even after 70 years of its independence, is still a developing nation. More than 60 percent of the Indian population reside in rural area. Some refer to this rural area as the ‘Bharath’ while the urban as ‘India’. Lot of industrialisation has taken place since 1947, but has failed to achieve equitable growth. Former Prime Minister of India Dr. Manmohan Singh once said “the key to our success lies in the success of manufacturing in the small scale sector” (Garg and Wali [14]). The World Bank Review on Small Business Activities establishes the commitment of the World Bank Group to the development of the small and medium enterprise (SME) sector as a core element in its strategy to foster economic growth, employment and poverty alleviation (Ayyagari et al. [4]). Development of MSMEs would result in decentralized industrial expansion, better distribution of wealth, and encourage investment (MSME Annual Report [33] and [34]).

Syal [43] asserts that the micro, small, and medium enterprises are the engines of economic growth and they are a means in achieving equitable development. Many researchers (Ayyagari et al. [4]; Unnikrishnan et al.[51]; Katyal and Xaviour [25]; Lahiri [28]; Uma [50]; Tripathi and Tripathi [49]; Farajollahzadeh et al. [13]; Das [8] and Dr. Uma Pujar M.Com.[11]; Metha [32] and Tripathy [46] ) argue that the impact of SMEs to the economy of the nation in terms of its contribution to GDP, export, and employment are significant.

The number of working enterprises (MSMEs) in India has grown by 140 percent in just years. The compounded annual growth rate has been 4 percent during these years. The number of enterprises from 2006-07 to 2014-15 is presented in Figure 1. This sector has generated a large amount of employment. The annual growth rate in employment has been very consistent at 5 percent over the eight years from 2006-07 to 2014-15. It has provided employment to more than 11 percent of the Indian population in 2014-15. The number of employment during these eight years is shown in Figure 2.
Figure 1. Total Number of Working MSMEs (in Lakhs) in India
(Source: MSME Annual Report 2016-17)

Figure 2. Employment in MSMEs (in Lakhs) in India
(Source: MSME Annual Report 2015-16 and 2016-17)

It can be seen from Figure 3 that the MSMEs contribution to the export has been increasing since 2008-09. The compounded annual growth rate has been in excess of 20 percent. It can also be observed from the same Figure that during the year 2014-15 it has crossed 40 percent, which is substantial.

Figure 3. MSMEs’ Contribution to Export as Percent of Total India’s Export
(Source: Directorate general of commercial intelligence & statistics (DGCI&S) and Compiled from data given by Ministry of MSME; Ministry of Commerce and Industry, Govt. of India, Farajollahzadeh, Noorinasab, and Pradesh [13])
2.2 Energy Management

Energy is essential to achieve economic, social, and environmental objectives of sustainable human development (Kumar and Vimala [23]). The relationship between use of energy and economic growth has been a subject of inquiry as it is considered to be one of the important driving forces of economic growth in developed and developing countries (Pokharel [35]). Energy is one of the essential inputs to any MSME. To support the growth of MSME, the governments need to supply continuous and reliable energy (Thiruchelvam et al. [47]). For any country, the effective energy supply and appropriate use of it is a primary condition for economic development (Ates and Durakbas [3]). One of the main pillars of modern industry is the uninterrupted supply of energy at a reasonable price (Javied et al. [22]).

The energy generation and consumption have led to environmental hazards such as green house gases (CHG) emission and deforestation. Indian Ministry of Environment and Forests, in its 2012 report, mentioned that 70 percent of all industrial pollution is caused due to the activities of SMEs. Further, the report asserts that there is a greater need for improvement in production processes. Chan et al. [5] assert that the GHG concentration resulting from anthropogenic actions such as emission from factories has risen swiftly ever since industrial revolution. Based on the studies conducted in Taiwan, they said that industrial sector contribute significantly to GHG emission hence, mitigating GHG emission from this result in overall reduction of GHG concentration. They assert that there is a greater need to analyse the energy use to improve energy efficiency to reduce GHG and energy consumption as CO\textsubscript{2} emission is an environmental issue.

Singh et al. [42] mentioned that energy saving measures could be one of the ways to reduce GHG emission. They propose, based on their findings, that energy saving is possible by using efficient electric motors, boilers, compressors and lighting facilities. They assert that 10 – 30 percent reduction in GHG emission can be achieved at little or no additional cost by improving energy efficiency. Adopting new or up-graded technologies reduces GHG emissions (Priambodo and Kumar, [37]).

Schulze et al. [40] reviewed previous findings on energy management in industries. Based on their review reported that energy management leads to large energy consumption which remain untapped. Energy management is considered as a combination of energy efficiency activities, techniques and management of related processes which result in lower energy costs and CO\textsubscript{2} emission (Kannan and Boie [24]; Christoffersen [6]). Energy management helps achieve competitiveness (Posch et al. [36]). Anisimova [2] conducted studies in Russia and noted that there is a lack of information on positive effects of the application energy management system. Further, the researcher asserts that the top management is merely interested in obtaining the certification.

2.3 Energy Usage in Indian Industries

Various sources of energy prevail in India. They include electrical energy, thermal energy, and natural gas energy. But, the primary source of energy for the SSIs is electricity and is to the tune 76 percent. The electricity energy consumed by MSMEs from 2006-07 to 2014-15 is shown in Figure 4. Subramanian and Ramachandra [44] conducted a survey of SSI units in Karnataka and based on their analysis, they assert that the energy saving potential in SSI is to the extent of 32 percent. This can be achieved by moving the low- and medium-efficiency units into high efficiency units.
Population in India is on the rise more than ever. The demand for electrical energy is also on the rise. But, the generation of electrical energy do not match the requirement. Government of India is importing electrical energy to match the demand. The amount of electricity imported during 2006-07 and 2014-15 is shown in Figure 5. This adds to the pressure on trade deficit. The GHG emitted is shown in Figures 6.

MSME emission includes on site emission (direct emission) and emission form electricity generation at a separate power station (indirect emission). The indirect GHG emissions as show in the Figures 6 make up 25 percent of the total industrial CO₂ emission (Shakti Sustainable Energy Foundation(SSEF) [41]. The indirect emissions are 0.93 kgs of CO₂, 0.00707 kgs of SO₂, 0.0046 kgs of CO and 0.0043 kgs of NO per kilowatt-hour of power generation form coal (Ghodke, Kumar, and Singh [17]; Saxena [39]). Direct emission father classified in to 1. Fuel combustion emission: combustion of fuel (liquid or solid) to generate heat for various production processes 2. Process emission: emission due to chemical reaction during the process of production.
3. Energy Saving Possibilities in SMEs

Abdelaziz et al. [1] based on the works of Tenaga [45] and Tripathy [46] puts forth that high efficient motors offer many benefits. They are: less maintenance and longer life time due to lower temperature in windings and bearings and higher reliability due to lower losses. Saidur and Mekhilef [38] conducted studies in rubber producing industry and found that conventional motor when replaced by variable speed driver motor results in reduction of 202 billion kWhr of electricity and CO$_2$ emission by 79 million tonnes per year with a payback period of 3 years. They also found that the compressors with appropriate leak proof result in 20 percent of total consumption. IEA [21] reported that the traditional vacuum evaporation system replaced by Nanofiltration not only reduces energy consumption but also economical. Deore [10] conducted studies in seven forging SMEs and fourteen dal and poha processing units in Indore and Ujjain reported that replacement of inefficient motors and compressors when replaced by modern ones resulted in substantial annual energy saving. They also conducted studies in brick manufacturing units, sea food units, and hand tool units. They found that with modernisation substantial electrical energy savings is possible with reduction in CO$_2$ emission also.

Dasgupta [9] conducted research in metallurgical, cotton dyeing, and manmade textile SMEs in Ludhiana and Surat. He found that the metallurgical organisations are using traditional cupolas. With little modification in insulation reported a possible energy savings of 20 – 25 percent. In all other type of organisations with slight modification in the processes the power usage and hence, the power cost could be reduced by 50 percent.

Thirusevam et al. [47]; Chan et al. [5]; Hasanbeigi [19] and Price et al. [26], have conducted studies in Textile industry (SMEs). They found that energy efficient motors and appropriate insulation of kilns bring in lot of benefits. They reduce the dust generation by about 50 percent. They also studied the economics of such replacements and found that the payback period would be around 16 months.

Thirusevam et al. [47] and Mathur [29] conducted studies in tea industries in Srilanka and Southern India. They found that energy efficiency measures have the potential to reduce that energy cost by about 30 percent. Mathur, [29] further found that this would reduce the CO$_2$ emission by about 55000 tonnes annually. This would finally reduce the cost per kg of tea by Rs 2.

Griffin [16], IAC [21], and Galitsky et al. [15] conducted studies in food industry. They reported that proper maintenance of steam system and boiler can reduce the energy consumption by 8 percent. CoA [7] and IAC [21]) reports on the same industry reported that insulation and leak free gas circulation cane reduce the energy consumption by about 15 percent. The report has a mention of compressed air
for cooling when replaced by blowers brings in a reduction of energy consumption by about 25 percent.

The energy saving opportunities as reported in various studies conducted by different researchers in enumerated in Table 1 below:

| Type of Industry                  | Energy Saving Measures                                                                 | Annual savings                                                                 | Reduction of Industrial Operating Cost | CO2 Emissions Reduction in Million Tonnes | Authors                  | Payback period |
|----------------------------------|----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|----------------------------------------|------------------------------------------|--------------------------|-----------------|
| Rubber producing                 | Electrical motor VSD Motor                                                               | In Europe up to 202 billion kWh in electricity                                 | €10 million in electricity per year    | Not reported                             | Saidur and Mekhilef [38] | 3 years         |
|                                  | Compresse d air Leak prevention                                                         | 20% total energy consumption                                                   | Not studied                            | Not reported                             | Not studied              |                 |
| Cheese Factory                   | Vacuum evaporation Nanofiltration                                                        | Eliminates natural gas consumption and reduces electricity use by more than 25%.| USD 1.5 million per year               | Not reported                             | IEA, [20]                | 8 months        |
| A cucumber and tomato grower     | Conventional boiler for a large greenhouse complex                                        | Of money savings alone for electricity and gas                                   | Not reported                           | Not reported                             | EBRD [12]               | 4 years         |
| SME around the World             | Better maintenance and turning off appliances and equipment when not needed             | 5% to 20% of energy demand                                                      | Not reported                           | Not reported                             | EBRD [12]               | Not reported    |
| More than 1500 SME forging units | Existing Heating Furnace & Special Purpose Machines                                      | 20 to 40% Energy                                                                | Post implementation audits at 7 units of Forging Cluster in Ludhiana, 7 units of Food Cluster in Indore and 1 unit of Brick Manufacturing cluster in Deore [10] | Not reported |                   |
| 14 Food (Dal and Poha) processing units in Indore and Ujjain industrial area | Inefficient motors, compressor system, EE motors, Oxygen Sensor, fuel control and damper control, VFDs, EE compressor | 15 to 30% Energy                                                               | These 15 verified units has yielded 750 tonnes of CO2 per annum | Deore[10] | Not reported |

Table 1: Energy Saving and CO₂ Emission Reduction in SMEs
| Type of Industry | Energy Saving Measures | Reduction of Industrial Operating Cost | CO2 Emissions Reduction in Million Tonnes | Authors | Payback period |
|------------------|------------------------|----------------------------------------|------------------------------------------|---------|----------------|
| 300 Brick manufacturing units in the cluster, Varanasi Brick Cluster | Old Technology | Modern Equipment/ Machines/ Technology | Annual savings | Varanasi. Energy Savings of about 305 toe per annum, Cost Savings of about INR 1.5 crore per annum | Deore [10] | Not reported |
| Thangadh Ceramic Cluster | Ordinary fans are 75W | 28W EE ceiling fans, around 7500 EE fans | 14 Lakh units Power (65% electricity) | 1400 tonnes of GHG emission per year | Deore [10] | Not reported |
| Kochi – Sea Food Cluster (14 Units) | Reciprocating compressor | Screw compressor with VFD, Thermoshipon System (Gas Cooling) for Compressor. | 15 to 20% Energy | Not reported | Not reported | Deore [10] | Not reported |
| Jalandhar Hand tool Cluster | Ordinary fans are 75W | 28W EE ceiling fans, around 5 EE fans | 65% Electricity | Not reported | Not reported | Deore [10] | Not reported |
| Metallurgy industry: | Batch furnace | Continuous production furnace | 20% fuel saving on average | Not reported | Reduces pollution considerably | Dasgupta [9] | |
| | Existing cupolas | Modification of Existing cupolas | 20 to 25% fuel saving. | Not reported | Not reported | Dasgupta [9] | |
| Cotton dying(Ludhiana) | Separate scouring and bleaching of fabric and acid treatment | Simultaneous scouring and bleaching of fabric Rinsing and acid treatment reduced | Steam and power costs down 50% and 30% respectively | Not reported | Not reported | Dasgupta [9] | Not reported |
| Manmade Textiles (Surat) | Jet dyeing machine and Direct fired gas | Thermic fluid heating and dye bath reuse | Fuel and power costs down 50% and 95% respectively | Not reported | Not reported | Dasgupta [9] | Not reported |
| Textile Industry | Convention al motors in ring | Energy efficient motors | Not studied | US $426 per annum | Not reported | Thiruce vam ,et al. | 16 Months |
| Type of Industry | Energy Saving Measures                                                                 | Annual savings | Reduction of Industrial Operating Cost | CO2 Emissions Reduction in Million Tonnes | Authors                                      | Payback period |
|------------------|----------------------------------------------------------------------------------------|----------------|----------------------------------------|-------------------------------------------|---------------------------------------------|----------------|
|                  | Frame in spinning mills                                                                 |                |                                        |                                            | [[47]; Chan et al.; [5]; Hasanbegi and Price [26]] | 15 Months       |
|                  | Biomass fired kiln                                                                      | 50% Fire wood  | US $ 1110 per annum                    | 50% reduction on dust                     |                                             |                |
| Tea Industries   | Convention al                                                                          |                |                                        |                                            | Thirucevam et al. [47]                      | 3.5 Years       |
| Mooloya Srilanka | Constructed a mini hydro plant                                                          |                | Rs564000/year                          | Not reported                              |                                             |                |
|                  | 60 Tea Factory                                                                        |                |                                        |                                            | Mathur [29]                                 |                |
| Southern India   | Convention al                                                                          |                |                                        |                                            |                                             |                |
|                  | Adopting Energy efficiency measures                                                    | 30% Energy cost| Rs 2/kg of Tea                         | 55,800 tonnes of CO2 annually             |                                             |                |
| Pulp and Paper Industry | Conventional pumps                                                                    |                |                                        |                                            | Klugman, [27]                               | Not reported    |
|                  | Energy efficient pumps                                                                  | 50% of Electricity |                                            |                                            |                                             |                |
|                  | Worn out pump                                                                          |                |                                        |                                            | Klugman, [27]                               |                |
|                  | Energy efficient pumps                                                                  | 30% of Electricity |                                            |                                            |                                             |                |
|                  | Conventional motor                                                                     |                |                                        |                                            | Klugman, [27]                               |                |
|                  | Energy efficient motor                                                                  | 30% of Electricity |                                            |                                            |                                             |                |
|                  | Cooling towers, pumps and electric fans Control                                         |                |                                        |                                            | Klugman, [27]                               |                |
|                  | Add inverters to cooling towers, pumps and electric fans                               | 30% of Electricity |                                            |                                            |                                             |                |
|                  | Control the discharge oxygen concentration of the boiler; and prevent discharge        |                |                                        |                                            |                                             |                |
|                  | temperature from exceeding the designed specification                                  |                |                                        |                                            |                                             |                |
|                  | Boiler                                                                                 |                |                                        |                                            |                                             |                |
|                  | Coal boiler (Muzafarnagar)                                                              |                |                                        |                                            |                                             |                |
|                  | Biogases boiler                                                                        |                |                                        |                                            |                                             |                |
|                  | Steam and power costs down 50% and 30% respectively                                     |                |                                        |                                            |                                             |                |
|                  | Conventional Melting furnace (new induction furnace)                                    | 23% of Electricity, 51% LPG and 70% District |                                            |                                            |                                             |                |
| Foundry          |                                                                                       |                |                                        |                                            |                                             |                |
|                  |                                                                                       |                |                                        |                                            |                                             |                |
| Type of Industry | Energy Saving Measures | Existing Equipment/ Machines/ Technology | Modern Equipment/ Machines/ Technology | Annual savings | Reduction of Industrial Operating Cost | CO2 Emissions Reduction in Million Tonnes | Authors | Payback period |
|------------------|------------------------|-----------------------------------------|----------------------------------------|----------------|----------------------------------------|--------------------------------------------|---------|----------------|
| Glass Industry  | Existing no heat recovery system | Recuperator | Energy efficiency measure such as New sand preparation, compressed air | heating (2300MWhr/year saving) | Not reported | Not reported | Ministry of Economic Trade and Industry [29] | Not reported | 0.5 year |
| Chemical Industry | Air Compressor | Efficiency management, maintenance, and leakage control. | Efficiency management, maintenance, and leakage control. | 20 to 30% energy | Not reported | Not reported | Not reported | Not reported | Not reported |
| | Water heat recycling from boiler and condenser | Installation of heat exchanger | Installation of heat exchanger | 20 to 30% energy | Not reported | Not reported | Ministry of Economic Trade and Industry [29] | Not reported | Not reported |
| | Cooling tower | By adding inverter to pump and electric motor | By adding inverter to pump and electric motor | 20 to 30% energy | Not reported | Not reported | Ministry of Economic Trade and Industry [29] | Not reported | Not reported |
| Food Industries | Steam system and boiler | Proper Maintenance | Proper Maintenance | 3–8% reduction in fuel consumption | Not reported | Not reported | Griffin, [16]; IAC, (21); and Galitsky et al. [15] | 1.7 year | |
| | Oven and control system | Insulation, air leak free, recovering exhaust gas | Insulation, air leak free, recovering exhaust gas | 5 to 15% energy saving | Not reported | Not reported | CoA [7]; IAC, [21] | 2 to 4 years | |
| | Compressed air for cooling | Blowers | Blowers | 25% energy saving | Not reported | Not reported | CoA [7]; IAC, [21] | 1 year | |
4. Conclusions

An extensive literature was carried out. Many researchers assert that SMEs play a vital role in the development of any nation, more so in the developing countries like India. They contribute significantly to the growth of the nation in the form of employment generation, GDP, and export. They are also the substantial consumers of electrical energy. SMEs also significantly contribute to CO₂ emission. The literature review reveal that the compressor air leakage prevention and use variable speed drive motor can affect exorbitantly an energy saving. In addition to this the proper insulation of heat exchanger, boiler and use of inverters can play major rule in the possible reduction in energy consumption. Also it is emphasised that a proper maintenance of the mechanical equipment will go a long way in reduction of energy consumption. The above factors not only saving the energy but also bring down the total cost and Green house gasses. If these measures are employed in SMEs of Karnataka, there could be lesser pressure on Government to supply electrical energy and lesser pressure on environment.

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