Electrification As A Decarbonisation Option For Thermal Applications In The SME Sector In India

Shirish Bhardwaj, Alliance for an Energy Efficient Economy
Bhaskar Natarajan, Alliance for Energy Efficient Economy

ABSTRACT

The energy diet of the world is changing due to the traction towards non-fossil energy sources. India also has committed to attaining 50% of its total electric power installed capacity through non-fossil fuel-based energy resources by 2030. It is well understood that electricity (direct or indirect) as an energy vector is the fastest way to integrate non-fossil energy sources and hence becomes the most efficient option for the decarbonisation of Industrial sectors. Studies suggest that nearly two-third of the total energy consumption by Indian industries is primarily for heat requirements in various processes. This study focuses on the Small and Medium Enterprises (SME) sector in India and assesses the potential of electrification of thermal process in the foundry, forging, and textile sectors. The study also estimates the potential for reduction in Greenhouse Gas (GHG) emissions due to electrification in these sectors across India. This paper is based on the case studies from each of the industrial sectors where energy-intensive industrial utilities like furnaces and boilers are used. These utilities consume 80-90% of the total energy in these industrial sectors and are considered in this study for electrification. Furthermore, based on the interaction with industry associations and sector experts, the study highlights the challenges pertaining to electrification and suggests policy recommendations for the identified sectors to transit towards the electrification of energy-intensive utilities.

Background And Context

India is one of the fastest-growing economies in the world, and as a result, it has seen significant growth in the Small and Medium-sized Enterprise (SME) sector. However, the SME sector in India is heavily reliant on fossil fuels for thermal applications, such as heating and cooling, which contributes significantly to greenhouse gas emissions. In recent years, there has been an increased focus on decarbonisation, and electrification has emerged as a potential option for reducing emissions from thermal applications in the SME sector. The use of electric heat pumps, electric boilers, and electric furnaces can reduce the reliance on fossil fuels for applications like heating, drying, cooling, and others.

The Indian government has set ambitious targets for reducing greenhouse gas emissions and transitioning to a low-carbon economy. The country has pledged to reduce its emissions intensity (emissions per unit of GDP) by 45% by 2030, and to increase the share of non-fossil fuels in its electricity mix to 50% by 2030 (PIB 2022). Achieving these targets will require significant changes in the way energy is generated and consumed in India, particularly in the SME sector. This sector is responsible for 25% of the total energy consumption by Industrial sector in India (TERI 2022).

Small and medium-sized enterprises (SMEs) are essential for economic growth, job creation, and social cohesion in both high-income and emerging economies, as well as lowincome developing countries. They have the potential to play a vital role in sustainable and inclusive economic growth, development, and financial stability.

The textile, foundry and forging sectors has a significant environmental impact worldwide as it generates a substantial amount of carbon emissions. This is primarily because the production processes involved in these sectors are very energy-intensive and the scale of manufacturing under these sectors each year is enormous. Furthermore, the energy utilities in these units are outdated and less efficient leading to excess usage of energy than required. For instance, in the Indian textile units, the boilers used have thermal efficiencies in the range of 35-50%, compared to the latest boilers that can provide the efficiencies in the range of 65%-70% (BEE 2016) under best operating conditions. Similarly, in the forging and foundry sector the conventional copula furnace has efficiency in the range of 40%-70% (HEMANT R. BHAGAT-PATIL 2013), whereas an induction furnace has efficiencies in the range of 80% - 90% (BEE 2017). The technologies like electric boilers and induction furnaces for process heat purposes are readily available can be deployed at scale in these sectors.

Overview Of The Foundry, Forging, And Textile Sectors In India

Textile Sector

India has a thriving textile industry that is renowned worldwide, owing to its extensive raw material base and robust manufacturing capabilities throughout the value chain. The industry contributes 7% to the country's industry output in value terms, 2% to its GDP, and 12% to its export earnings (Rathee 2023). It is the second-largest textile and clothing manufacturer and exporter in the world, after China, and accounts for a substantial 12% of the country's total exports. India has a 5% share of the global trade in textiles and clothing (Rathee 2023). What sets the industry apart is its proficiency in both hand-woven and mill sectors, with the latter being the second-largest in the world. The industry provides employment opportunities to millions of people in rural and semi-urban areas, particularly in traditional sectors such as handloom, handicrafts, and small-scale power-loom units.

It is also one of the biggest employment generators in the country, directly employing over 45 million people, including a large number of women and the rural population, and supporting another 60 million people in allied sectors. The Government's focus has been on promoting textile manufacturing and enhancing the industry's infrastructure, technology, skills, and traditional strengths, in line with its initiatives such as Make in India, Skill India, Women Empowerment, and Rural Youth Employment, and to ensure inclusive and participative development.

From an energy perspective, the textile industry is a significant consumer of both thermal and electrical energy. The chemical processing of fiber, yarn, and fabric requires a considerable amount of thermal energy, while spinning and weaving rely on electrical energy. In fact, in a fabric processing house, thermal energy consumption can account for as much as 70-80% of the total energy consumed by the processing unit (Saurabh, et al. 2013). This highlights the importance of optimizing the use of thermal energy in the chemical processing of textiles to reduce energy consumption and improve efficiency.

A simplistic schematic of the processes involved in textile industry is depicted in Figure 1.

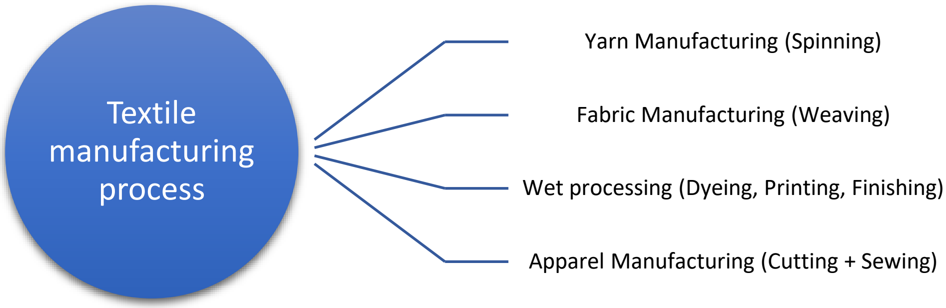

Figure 1: Process overview in textile industry

Yarn Manufacturing

Yarn manufacturing is an essential process in the textile industry. Yarn is a long continuous length of fibres that is used for knitting, weaving, or making fabric. The process of making yarn from fibres involves several steps, including: preparing the fibre; spinning; ply twisting; winding.

Fabric Manufacturing

Fabric made from fibres or yarns has a flat, two-dimensional structure that is created by weaving, nonwoven processes, or knitting. These techniques produce an interlocking pattern of fibres that can be categorized into three main types: woven, nonwoven, and knitted.

- Weaving is a process of interlacing two sets of yarns or threads at right angles to form a fabric. The process of weaving involves several steps, which can vary depending on the type of fabric being produced.
- Nonwoven manufacturing techniques involve a continuous procedure where two consecutive machines are used for web laying and web bonding. Typically, the formation of nonwoven materials comprises two fundamental stages: web formation and bonding. The web formation process is crucial in determining the performance of the final product in its intended application.
- The knitting process in textiles involves interlocking loops of yarn or thread to create fabric. It can be done by hand using knitting needles or by automated machines. It allows for flexibility in fabric production and is used to make garments, accessories, and various textile products.

Wet Processing

Wet processing is an essential step in the textile industry that involves a series of processes to enhance the quality and value of fabrics. It typically involves the use of water, chemicals, and various mechanical and thermal treatments to alter the physical and chemical properties of textile materials. Here are some of the common steps involved in wet processing:

- Pre-treatment: The first step in wet processing is pre-treatment, which involves preparing the fabric for subsequent treatments. This process removes any impurities, dirt, or oil present in the fabric by washing it with water and detergent.
- Scouring: Scouring is a process that involves the use of chemicals to remove natural impurities from the fibres. It helps to improve the absorbency and dyeing properties of the fabric.

- Bleaching: Bleaching is a process that uses chemicals to remove any remaining natural colour in the fibres. This step is often done to prepare the fabric for dyeing.
- Mercerization: Mercerization is a process that treats the fabric with caustic soda solution to increase its strength, lustre, and dye uptake. It also improves the fabric's ability to resist wrinkles and shrinkage.
- Dyeing: Dyeing is a process that involves adding colour to the fabric. There are several types of dyeing methods, including direct, reactive, and vat dyeing.
- Printing: Printing involves applying a design onto the fabric using different techniques such as screen printing, roller printing, or digital printing. The design is applied using coloured pigments or dyes.
- Finishing: Finishing is the final step in wet processing, and it involves a series of processes to improve the fabric's properties such as softness, water repellence, or flame resistance.

Overall, wet processing is a critical step in the textile industry that helps to enhance the quality and value of fabrics. However, it is also an energy and resource-intensive process that requires careful consideration of environmental impacts and sustainability.

Apparel Manufacturing

Apparel, which is a term used to refer to clothing, is the end product of the textile industry. The process of designing and producing apparel involves a blend of contemporary art and technology. Over time, apparel manufacturing has witnessed significant progress in design development, including the integration of computer-aided manufacturing (CAD) and automation.

Energy Consumption in a typical Textile unit

In a typical unit of a cluster in the textile industry, a variety of energy sources are used to power various processes involved in textile manufacturing. The primary energy forms used in this industry include electricity, natural gas, lignite, non-renewable wood biomass, and imported coal.

Electricity is primarily consumed by pumps, fans, drives, and lighting. These devices require a reliable source of electricity to function optimally and ensure the smooth running of the manufacturing process. Additionally, electricity is essential in powering various computer systems and control panels that help to monitor and control the various stages of production.

Lignite and imported coal are primarily used as fuel sources in boilers to generate steam. The steam generated is then utilized in several different processes, including dyeing, printing, and finishing. These processes require a significant amount of heat, which is produced by burning coal or lignite in a boiler. While these energy sources are readily available, they are non-renewable, and their combustion contributes to greenhouse gas emissions. Natural gas is also a widely used energy form in the textile industry. It is mainly used in heat setting processes for stenter's, which are machines used to give fabrics their desired shape, size, and texture. Natural gas is also used in generators that produce electricity to power some of the manufacturing processes.

Finally, another energy source i.e wood biomass) is used extensively in the textile industry. It is typically used in boilers to generate heat for various processes. While it is a renewable energy source, it can contribute to deforestation if not managed sustainably.

The share of fuels and electricity in the annual consumption of the textile cluster units is depicted in Figure 2.

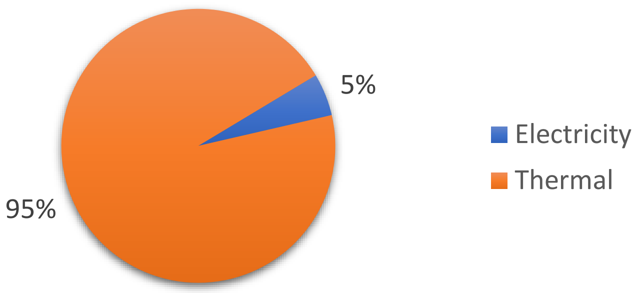

Figure 2: Share of thermal and electrical energy *Source:* (SAMEEEKSHA 2016)

In a typical unit of the cluster, the primary sources of energy used are electricity, natural gas, lignite, biomass materials such as wood, and imported coal. Electricity is utilized to operate pumps, fans, drives, and for lighting purposes. Boilers for steam generation use lignite and imported coal. Natural gas is consumed in heat-setting processes like Stenter's, and natural gas-based generators. The data provided in Figure 2 is based on the energy consumption in Surat, Panipat, Jetpur, Tirupur and Solapur clusters. Data from 8,765 units was analysed to find the composition of fuel mix in the clusters. Cluster-wise energy consumption in each of the clusters is provided in Figure 3.

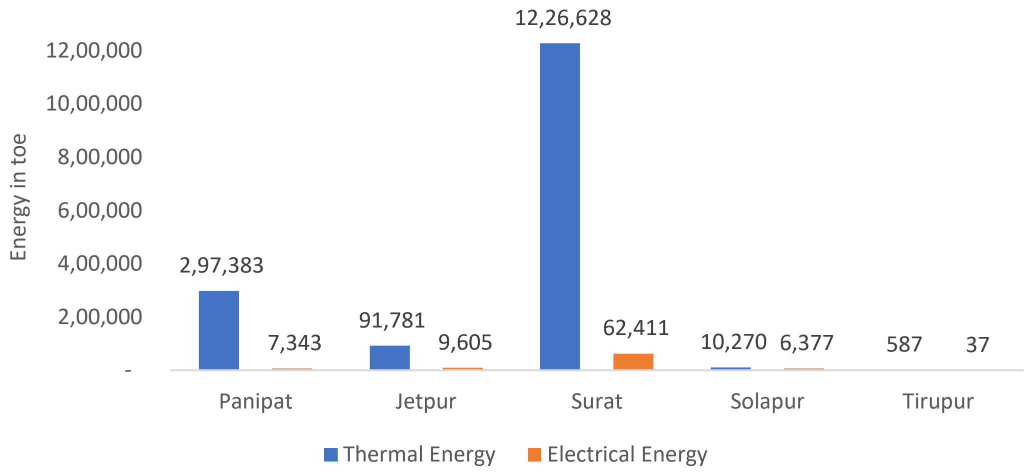

Figure 3: Cluster wise energy consumption share. *Source*: *(SAMEEEKSHA 2016)*

From the graph it can be observed that, in every cluster the thermal energy consumption is higher than the electrical energy consumption and hence there is a scope for energy and emissions reduction in these textile clusters.

Foundry And Forging Sector

The foundry and forging sector in India are a significant contributor to the country's manufacturing industry. The foundry and forging sector in India is primarily driven by the automotive and engineering industries. India is the world's second-largest producer of castings, with an annual production capacity of around 11 million metric tons (IBEF 2018). The industry also exports a significant portion of its products to countries like the US, Germany, and South Africa (Volza Grow Global 2023).

Foundry and forging are two different processes used in the manufacturing of metal components and products in India. While foundry is used to produce castings, forging involves the shaping of metal through the application of heat and pressure. A brief overview of the manufacturing process involved in both foundry and forging in India is provided below.

Foundry Manufacturing Process:

- Pattern Making: The first step in foundry manufacturing is the creation of a pattern or a model of the desired product using wood, plastic, or metal. The pattern is used to create a mould into which molten metal is poured.
- Mould Making: Once the pattern is ready, a mould is created around it using sand or a mixture of sand and other materials. The mould is made in two halves to allow for the removal of the pattern.
- Melting: The metal is melted in a furnace and brought to the desired temperature. The type of metal used depends on the requirements of the final product.
- Pouring: Once the metal is molten, it is poured into the mould through a gating system.
- Solidification and Cooling: The molten metal solidifies and cools in the mould to form the desired shape.
- Shakeout: After cooling, the mould is broken apart to remove the casting. The casting is cleaned and finished to remove any excess material.

Forging Manufacturing Process:

- Heating: The first step in forging manufacturing is the heating of the metal to a temperature above its recrystallization point. This makes the metal easier to shape.
- Forming: The metal is then placed in a forging press or hammer and shaped through the application of force.
- Trimming: Once the metal is formed, excess material is trimmed away using a cutting tool.
- Heat Treatment: The forged component is then heat-treated to improve its strength and durability.
- Finishing: The final step in the forging process involves finishing the component through processes such as machining, polishing, or coating.

The manufacturing processes involved in foundry and forging are complex and require skilled labour and advanced machinery. However, these processes are critical to the production of a wide range of metal components and products used in various industries in India and around the world.

Energy consumption is a significant concern in the foundry sector in India. Foundries consume significant amounts of energy, mainly in the form of electrical and thermal energy. Major energy sources being used in foundry cluster are electricity and fuels such as Coal, Furnace Oil, and Diesel. This depends on application of technology, process requirement, availability, and economic and safety point of view. Electrical energy is being used in melting of iron in induction furnaces, operation of electrical utilities and thermal energy is being used in cupola furnaces operation. The high energy consumption results in high carbon emissions, contributing to climate change and environmental degradation.

The share of fuels and electricity in the annual consumption of the foundry and foundry cluster units is provided in Figure 4:

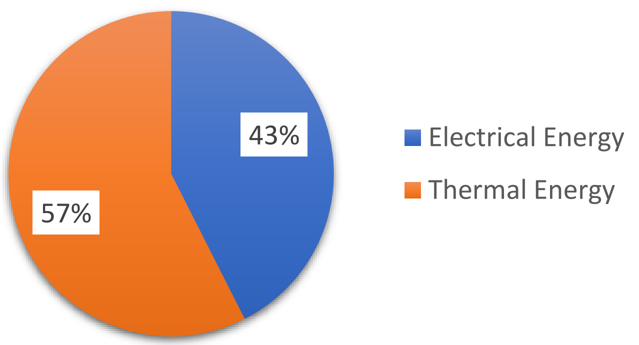

Figure 4: Energy share in foundry and forging sector. Source: (SAMEEEKSHA 2016)

The numbers provided in the figure are based on the data from 4,190 foundry and forging units across the country from 18 clusters including, Ludhiana, Agra, Jamnagar, Ahmedabad, Kolhapur, Belgaum and others. Cluster-wise energy consumption in each of the clusters in provided in Figure 5.

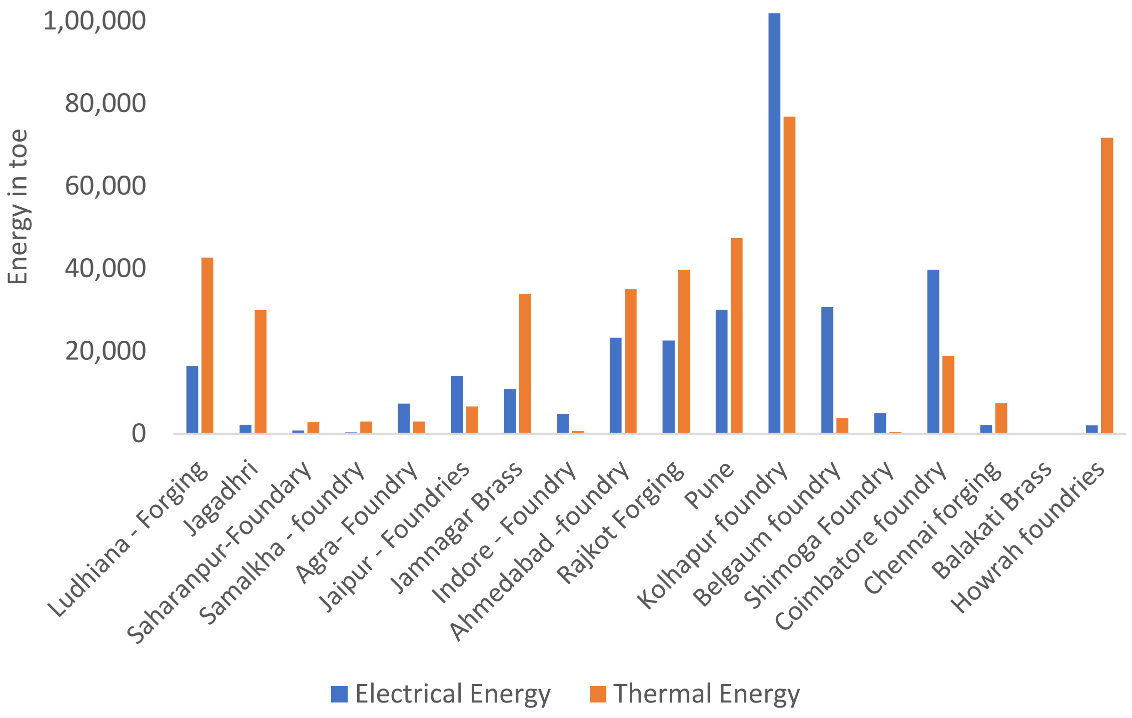

Figure 5: Cluster-wise energy share. *Source:* (SAMEEEKSHA 2016)

From the graph in figure, it can be observed that, in most of the clusters, thermal energy consumption is higher as compared to electrical energy consumption except from Agra, Jaipur, Indore, Kolhapur, Belgaum, Shimoga, and Coimbatore clusters. This depicts that there is a scope for electrification of thermal application in the foundry and forging clusters and hence will result in reduced energy consumption and GHG emissions.

Calculations And Analysis

Textile Sector

As seen in the previous sections, thermal energy required in the textile clusters in India is approximately 95% of the total energy consumed. Analysis from the five major textile clusters (Panipat, Jetpur, Surat, Solapur, Tirpur), 95% of the total energy accounts for 16,27,874 tonnes of oil equivalent(toe) of thermal energy and the rest 5% accounts for 85,773 toe of electrical energy.

The textile industry is a significant consumer of energy, and the manufacturing process requires large quantities of heat for various stages such as washing, dyeing, printing, and finishing. Traditionally, combustion boilers have been the primary source of heat generation in the industry, with fossil fuels being the most commonly used fuel source. Water-tube and fire-tube boilers are two of the most widely used types of combustion boilers in the textile industry.

However, with the increasing focus on sustainability and reducing carbon emissions, the industry is exploring alternative methods for heat and steam generation. Electric boilers have the potential to play a significant role in this transition. They have an efficiency rate of

95-99% (M. Jibran S. Zuberi 2021), which is significantly higher than traditional combustion boilers having efficiency in the range of 65%-70% (BEE 2016). This means that they can generate the same amount of heat and steam with less energy consumption and fewer emissions.

However, as renewable energy sources become more widely available and cost-effective, the use of electric boilers in the textile industry could become more prevalent. Electric boilers offer several benefits, such as zero emissions at the point of use and the potential for integration with renewable energy sources.

Energy savings potential after replacing conventional fossil fuels boilers with electrical boilers can be estimated using the below equation:

$$Energy\ savings\ potential = EC_{CB} - EC_{EB}$$

Where EC_{CB} is energy consumption by conventional boiler and EC_{EB} is the energy consumed by the electrical boiler.

Similarly, for estimating the GHG reduction potential the following equation can be used:

$$GHG\ emissions\ reduction = EC_{CB} * \left(EF_{fuels}\right) - EC_{EB} * (EF_{grid})$$

Where, EF_{fuels} is the emissions factor of fossil fuels used in the boiler for process heat applications and EF_{grid} is the emissions factor of the electricity grid in India.

Table 1 below depicts the emissions factors of different fuels used in the selected textile clusters.

Table 1: Emission factor of different fuel used in Textile clusters

Fuels	Emissions factor (kg CO2/toe)
Coal	4,229
Wood/Biomass	4,689
Natural Gas	2,349
Electricity	8,257

Note: The above calculations are based on the emissions factors provided in IPCC for stationary combustion.
Source: (IPCC 2006)

Fuel -wise carbon emissions in the clusters is depicted in Table 2:

Table 2: Fuel wise carbon emissions in textile cluster

Fuels	Fuel consumed (toe)	Carbon emissions (tCo2)
Coal	10,41,506	44,04,183
Electricity	85,773	7,08,254
Wood/Biomass	3,01,914	14,15,740
Natural Gas	2,83,230	6,65,249

From Table 2, it can be observed that, around 90% of the emissions from the textile clusters are due to thermal energy consumption and the rest 10% is due to electrical energy consumption.

Replacing conventional coal-based boilers with electrical boilers will significantly reduce the consumption of energy and hence the reduced carbon emissions. *Figure 6* depicts the reduction in carbon emissions after the replacement of conventional boiler with electrical ones. For calculations, the efficiency of coal-based boilers is taken as 65% and for electric boilers efficiency is taken as 95%. Also, the coal consumption from Table 2 is considered for calculations and is taken as feedstock for conventional coal-based boilers. Calculations are done based on the efficiency difference between coal-based boilers and electric boilers.

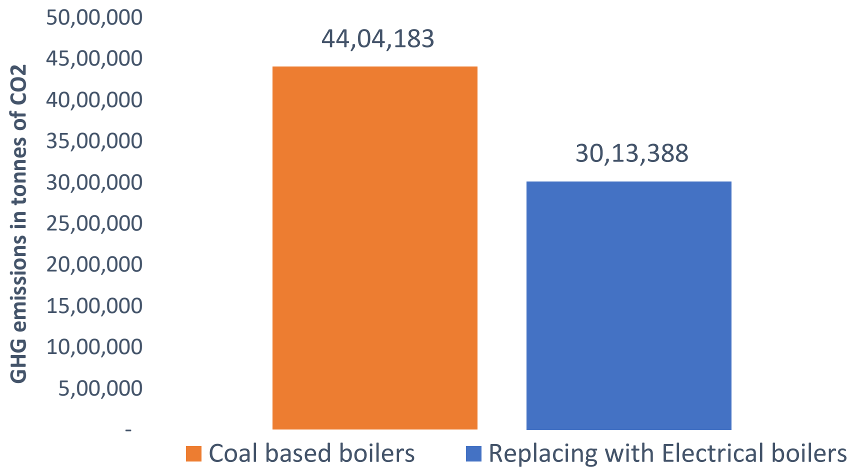

Figure 6: Reduction in emissions due to replacement of conventional boilers with electrical boilers

From Figure 8, it could be observed that a 31% reduction potential in carbon emissions due to coal consumption can be attained if all the conventional boilers are replaced with electrical boilers. Furthermore, the electricity grid currently has an emissions factor of approximately 700 grams of CO2 per kilowatt-hour, but this is expected to decrease to around 550 grams per kilowatt-hour by 2030 (TERI 2021) due to the renewable power targets set by the Government of India. Compared to fossil fuels, electric sources emit far fewer emissions over the lifetime of industrial equipment installed today. Additionally, electrical equipment is generally more energy efficient than its fossil fuel counterparts (IEA 2021). This means that even though electricity may have higher emissions per kilowatt-hour in the short term but due to lower energy requirements, the overall emissions impact is lower than that of fossil fuel equipment.

Foundry And Forging Sector

As discussed above, in foundry and forging clusters, 57% of the energy consumed is thermal energy and the rest 43% is electrical energy consumption. Small-scale foundries in India commonly use coal-fired cupola furnaces, which consume significant amounts of coke, resulting in substantial carbon dioxide emissions. To mitigate this, an alternative is to use electric induction furnaces, which are more energy efficient and have the potential to significantly reduce carbon dioxide emissions, depending on the source of the electricity used. With the ongoing decarbonization of the electricity sector, the induction furnace is estimated to already produce fewer emissions than the average cupola furnace. Hence, replacing coke-fired melting processes with electric induction furnaces can potentially lead to substantial emission reductions.

As compared to copula furnace which has efficiency of about 55% (Ajah SA 2022), the induction furnace is much more efficient having an efficiency of about 85% (TERI 2015), hence it can play a major role in decarbonising the foundry and forging clusters.

Similar calculations can be done for foundry and forging clusters as done for textile clusters. The equations for estimating the energy reduction potential and emissions reduction potential are presented as follows:

$$Energy\ savings\ potetnial = EC_{CF} - EC_{IF}$$

$$Carbon\ emissions\ reduction = EC_{CF} * \left(EF_{fuels}\right) - EC_{IF} * (EF_{grid})$$

Where EC_{CF} is the energy consumed by the conventional furnaces and EC_{IF} is the energy consumed by induction furnace for the same energy applications. The emission factors used are similar to the ones used for calculations in the textile sector in Table 1 with one additional fuel i.e. Furnace oil having carbon emission factor of 3,069 kgCO2/toe

Fuel -wise carbon emissions in the clusters is depicted in Table 3:

Table 3: Fuel-wise carbon emissions in the foundry and forging sector

Fuels	Fuel consumed (toe)	Carbon emissions (tCo2)
Coal	288,057	1,218,097
Wood/Biomass	20,314	95,257
Furnace Oil	95,855	294,173
Natural Gas	19,888	46,713
Electricity	313,966	2,592,514
Total	738,081	4,246,754

From Table 3, it can be observed that emissions due to thermal energy account for almost 40% of the total carbon emissions. These emissions can be reduced by replacing less efficient copula furnaces with induction furnaces. It is assumed that all the fossil fuel-based furnaces (coal based, furnace oil based, natural Gas based and biomass based) have efficiencies of about 55%. For calculations, thermal energy in the form of coal, biomass, furnace oil and natural gas are taken as feedstock to the furnace. This accounts for 424,114 toe of thermal energy. Calculations for emissions are done based on the difference in efficiencies of copula furnace and electric induction furnace.

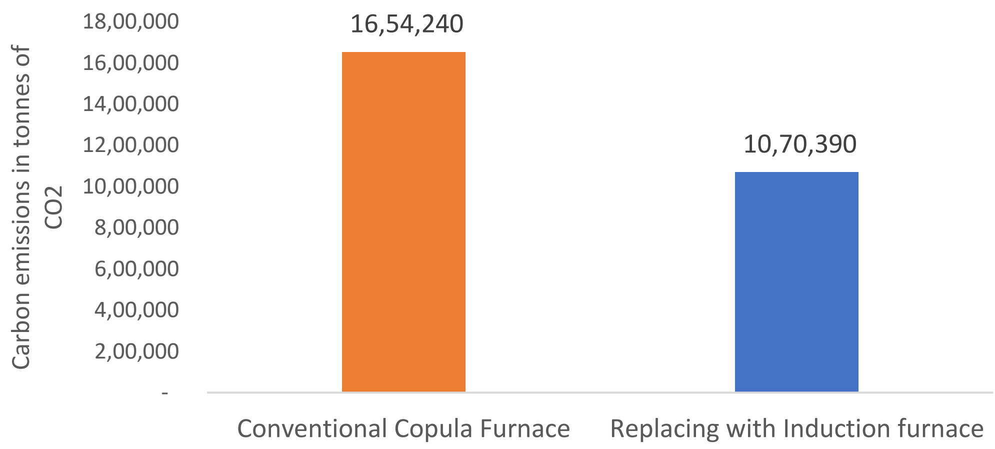

Figure 7: Emission reductions due replacement with induction furnace

From Figure 7, it could be observed that a 35% reduction potential in carbon emissions is there if all the conventional furnaces are replaced with Induction furnaces. The carbon emissions reduction that can be achieved is of the tune of 0.5 million tCO2.

Challenges And Opportunities For Electrification In SMEs

Electrification of thermal processes in SMEs (Small and Medium-sized Enterprises) in India faces several challenges, including:

- **Higher Initial Investment for electricity-based technologies:**

Electricity-based technologies typically require a higher initial investment in comparison to fossil fuel-based technologies. This is primarily due to the high cost of manufacturing, installing, and maintaining equipment like transformers, panels, and other infrastructure needed to connect to the electrical grid. Additionally, industries may need to make space available for this additional equipment, which can be a challenge, especially for small-scale industries that lack investment capital and access to commercial means of finance. As a result, industries may face a significant barrier to adopting electricity-based technologies.

- **Financial viability of electrification of fossil fuel-based processes:**

Although electrification of fossil fuel-based processes may offer several benefits, including reducing emissions and increasing energy efficiency, it may be financially unviable for industrial consumers. The high price of electricity for industrial consumers makes the electrification of these processes less cost-effective than continuing to use fossil fuels. As a result, industries may be reluctant to switch to electricity-based technologies and instead continue to rely on fossil fuel-based processes.

- **Low awareness of technical and financial feasibility of electrical technologies:**

Another challenge to the adoption of electricity-based technologies among industrial consumers is low awareness of their technical and financial feasibility, as well as their demonstrated track record. Many industrial consumers may not be familiar with the benefits and limitations of electricity-based technologies and may not understand the financial and technical requirements needed to implement these technologies. As a result, they may be hesitant to invest in and adopt these technologies.

- **Unreliable power supply:**

SMEs in India often face unreliable power supply and frequent power outages, which can be detrimental to the adoption of electricity-based technologies. This can lead to production downtime, lower productivity, and decreased efficiency.

- **Resistance to change:**

Some SMEs may be resistant to change and may prefer to continue using traditional fossil fuel-based processes, even if they are less efficient or more polluting. This can be due to a lack of awareness about the benefits of electrification or a belief that the costs associated with electrification outweigh the benefits.

- **Limited access to financing**

SMEs often has limited access to financing, which can make it difficult for them to raise the necessary capital to invest in electrification of thermal processes. This can be due to a lack of collateral, limited credit histories, or a lack of understanding of available financing options.

Overall, overcoming these barriers to the adoption of electricity-based technologies in industry will require greater awareness and education among industrial consumers about the potential benefits and challenges of these technologies, as well as innovative financing solutions to help industries overcome the high initial investment costs associated with the implementation of these technologies. Also, there is a need for concerted effort from policymakers, industry associations, and financial institutions to support SMEs in their transition to electrification, through providing financing, technical support, and awareness campaigns. This would not only help SMEs to reduce their carbon footprint but also contribute to the overall development of the country's sustainable energy sector.

Opportunities for electrification

To overcome the above-mentioned challenges, a few opportunities for electrifying the thermal applications are enumerated below:

- **Increased efficiency:** Electrification of thermal processes can increase efficiency and reduce energy consumption, resulting in cost savings for SMEs.
- **Improved productivity and process control**: The use of electricity-based technologies can result in improved process control, faster production times, and reduced downtime, which can lead to increased productivity.
- **Carbon credit trading scheme**: Reduced carbon emissions through the electrification of thermal processes can help to generate an additional source of revenue for the SME units and hence will reduce the payback period for electrification solutions.
- **Improved infrastructure**: The power sector is undergoing rapid changes through the augmentation of transmission and distribution infrastructure, and this trend is likely to continue in the future. Another factor driving changes in the power sector is the increasing adoption of smart grid technologies, which use digital communication and control systems to improve the efficiency and reliability of the power grid.

- **Environmental benefits**: Electrification can help SMEs to reduce their carbon footprint, contributing to sustainability efforts and enhancing their reputation as socially responsible businesses.
- **Expanding export markets**: These markets follow stringent ESG norms and require better monitoring and control over the negative impact of these process on the environment.
- **Access to incentives**: Government incentives, such as tax credits or subsidies, are often available to SMEs that invest in energy-efficient technologies, providing financial support to help offset the cost of electrification.
- **Access to new markets:** Adoption of electrification can help SMEs to access new markets that require environmentally friendly products or services, enhancing their competitiveness and market position.

Policy Recommendations

- The industrial electricity tariffs in India are complex, with significant variation in energy and demand charges across states and categories of industry. These tariffs are also higher compared to developed economies, hindering electrification and ease of doing business. Rationalizing industrial power tariffs can address these challenges.
- Low awareness of technical and financial aspects of electric technologies and their implementation hinder their dissemination. To address this, interventions such as feasibility studies, implementation assistance, policy dialogue, knowledge sharing, and awareness raising can promote electrification. Promotion of research and development of improved electricity-based technologies can also address non-availability of off-the-shelf solutions.
- Financial support is crucial for electrification efforts, especially when initial investment requirements are high and payback periods are unattractive. Government influence over financial institutions and power utilities can facilitate financial support. Business models developed by intermediaries such as R&D institutes and technology suppliers can bring financial institutions, utilities, and industry on a common platform to make access to finance easier.
- For small industrial users to shift towards electricity-based technologies, state governments and electricity distribution companies (DISCOMs) need to ensure easier electricity connectivity, reliability, and quality of power supply. Industrial users may need to enhance their electricity load, which may require costly and time-consuming infrastructure augmentation. Open access to power procurement can provide a choice to consumers for purchase of power from suppliers other than the DISCOM in whose license area they are situated. Implementation of open access can enable industry users to draw electricity at competitive prices and consider shifting from their existing thermal systems to electricity-based solutions.

References

Ajah SA, Idorenyin D, Ezurike BO, Nwokenkwo U, Ikwuagwu CV. 2022. “Thermal analysis to investigate the effects of operating parameters on conventional cupola furnace efficiency.” *Proceedings of the Institution of Mechanical Engineers.*

BEE. 2016. “Manual on Energy Conservation Measures in textile clusters in Tirupur .”

BEE. 2017. "Promoting Energy Efficiency and Renewable Energy in Selected MSME Clusters in India."

HEMANT R. BHAGAT-PATIL, MEGHA S. LONDHEKAR. 2013. "PERFORMANCE TESTING AND ANALYSIS OF CUPOLA FURNACE."

IBEF. 2018. "Indian Economy News." *India Brand Equity Foundation.* 04. Accessed 06 2023. https://www.ibef.org/news/india-becomes-second-largest-casting-producer-says-iif.

IEA. 2021. *Energy Efficiency 2021.* Accessed 2023. https://www.iea.org/reports/energy-efficiency-2021/executive-summary.

IPCC. 2006. "Guidelines for National Greenhouse Gas Inventories." Guidlines.

M. Jibran S. Zuberi, Ali Hasanbeigi, William R. Morrow. 2021. *Electrification of Boilers in U.S. Manufacturing.* LBNL.

PIB. 2022. *Cabinet approves India's Updated Nationally Determined Contribution to be communicated to the United Nations Framework Convention on Climate Change.* 03 08. https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1847812.

Rathee, Bhavna. 2023. *Textiles & Apparel.* https://www.investindia.gov.in/sector/textiles-apparel.

SAMEEEKSHA. 2016. *MSME Energy Map.* http://www.sameeeksha.org/index.php?option=com_content&view=article&id=247&Itemid=499#.

—. 2016. *SAMEEEKSHA - MSME Energy Map.* http://www.sameeeksha.org/index.php?option=com_content&view=article&id=247&Itemid=499#.

Saurabh, Mrinal, Piyush Verma, Ashok Kumar, and Bhaskar. 2013. "Indian Textile Industries Towards Energy Efficiency Movement." *International Journal of Environmental Science: Development and Monitoring* (International Journal of Environmental Science: Development and Monitoring).

TERI. 2015. "Energy Efficiency Best Operating Practices Guide for Foundries."

TERI. 2022. *Financing Low Carbon Transition in India's MSME Sector.* TERI.

TERI. 2021. *Potential for Electrifying Indian MSMEs.* Discussion Paper, New Delhi: TERI.

Volza Grow Global. 2023. *Exports from India.* Accessed 2023. https://www.volza.com/p/foundry-casting/export/export-from-india/.